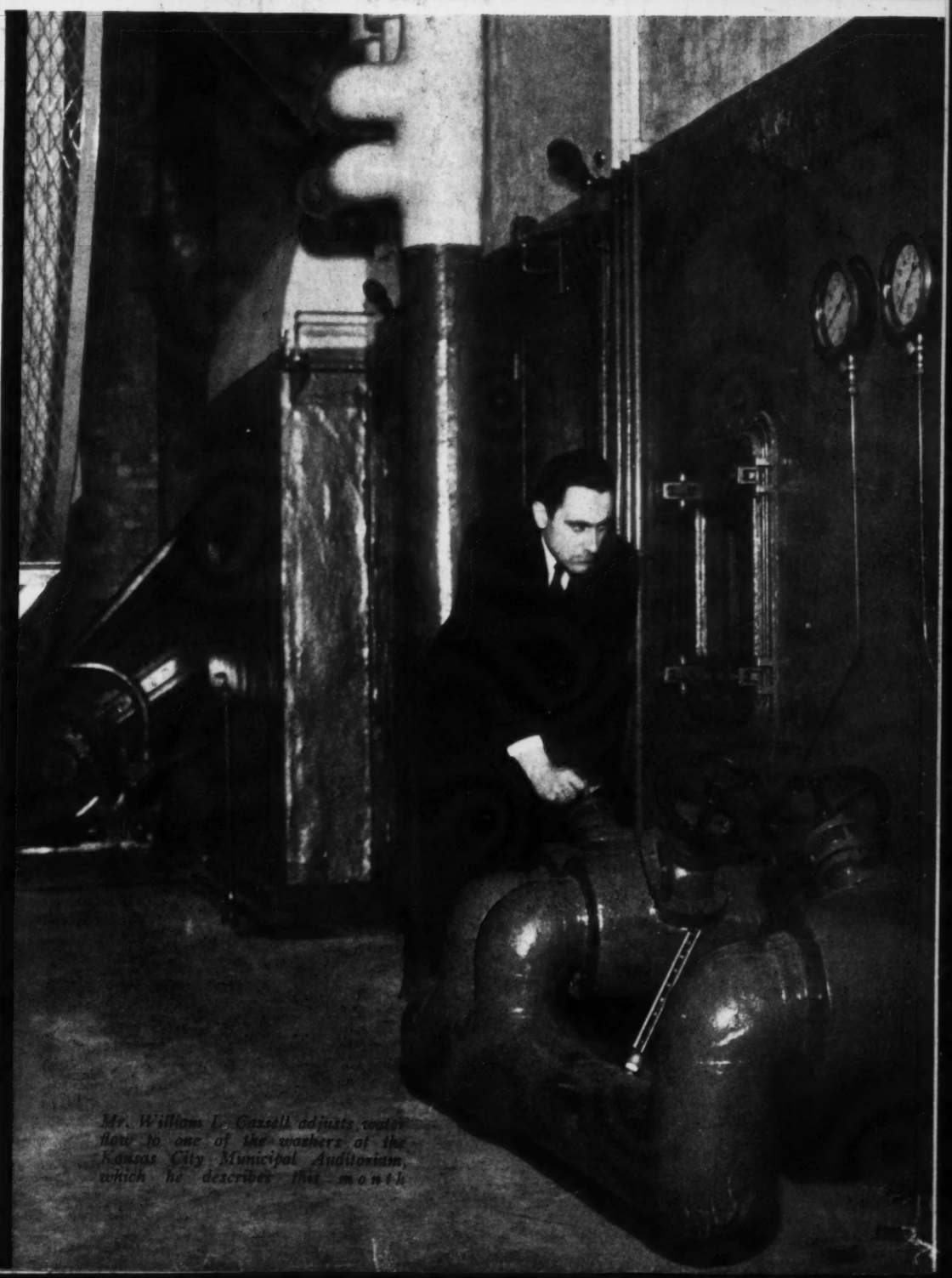
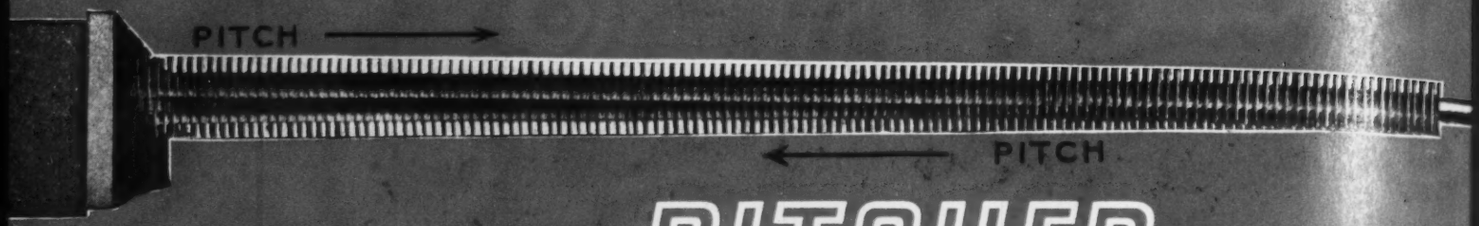
Table of Contents—Page 35

SEP 11 1936

Heating · Piping and Air Conditioning

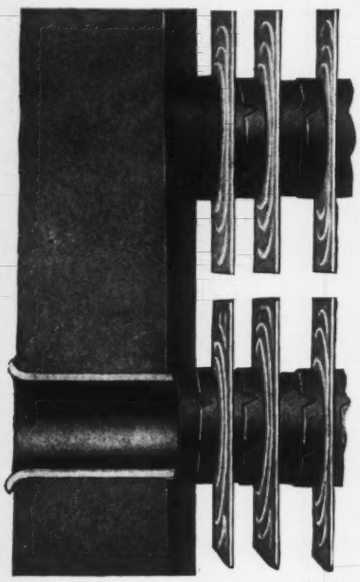


Mr. William L. Cassell adjusts water flow to one of the washers of the Kansas City Municipal Auditorium which he describes this month



CORRECTLY PITCHED TUBES

Plus HEAT EXCHANGER JOINTS

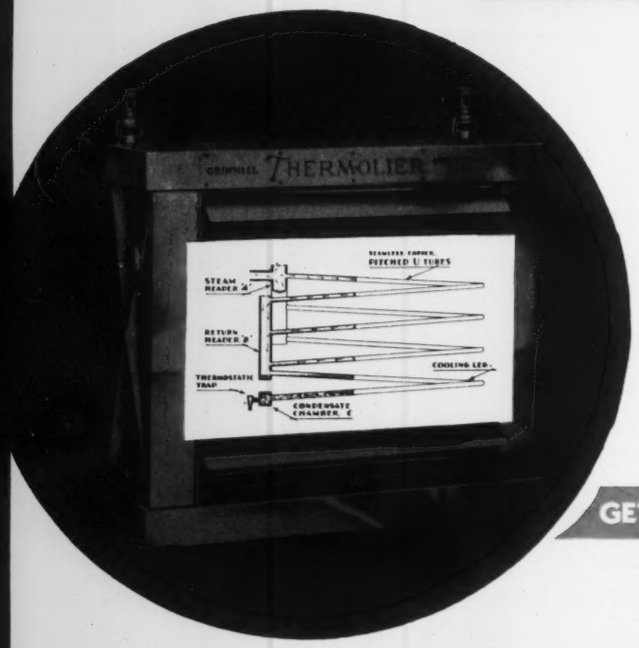


Mean EFFICIENCY and LONG SERVICE

At the top of this page we illustrate a single U-tube, of which there are many in each Grinnell Thermolier. Note the downward pitch of each leg. Thus Thermolier assures positive drainage of "Lazy Water" from each tube. Increases heating efficiency. Avoids the noisy and destructive "water hammer" that comes with collected condensation.

We also illustrate a cut-away section of the Thermolier "header". Note how the copper U-tube is expanded into the cast iron header. No corrosion. Safe for 125 pounds working steam pressure. With more than a half-million in operation, *not one of these joints has ever failed.*

These are only two of the fourteen points of superiority that save money and provide more heat per dollar from Thermolier.



GET THE FACTS!

Send for your copy of the Thermolier Data Book.

COLLECTS IN A THERMOLIER

GRINNELL COMPANY
EXECUTIVE OFFICES PROVIDENCE, R. I.
BRANCH OFFICES IN PRINCIPAL CITIES

GRINNELL THERMOLIER

THE UNIT HEATER WITH 14 POINTS OF SUPERIORITY

THE EDITOR'S PAGE • September, 1936

■ Work on a completely air conditioned building (the $650,000 Public Administration Clearing House Building) for the University of Chicago's campus will be started this fall, it has been announced. . . . Vol. 1, No. 1, of the Philadelphia Electric Co.'s "Air Conditioning News," published last month, headlines: "1936 Banner Air Conditioning Year—Hotels, Office Buildings, Banks, Apartment Houses 'Cash In' on Comfort Offered the Public." Publication was inaugurated because of the lively interest on the part of Philadelphia property owners seriously considering air conditioning, says the editor. . . . The "Business Conditioner," organ of the Omaha, Neb., Air Conditioning Bureau, advises placing contracts for air conditioning this fall to avoid the air conditioning rush, which will "probably be something like a mad house during the winter and spring," says that by contracting now, good engineering and careful and deliberate attention to all requirements will be guaranteed. . . . "Forbes" magazine is offering a prize of $100 for the invention of a single word to serve in place of the words "air conditioning," the contest closing September 15; air conditioning is "today's most promising infant industry," says the announcement. . . . The term "air conditioning" may have its faults, but it's going to be mighty difficult to replace.

■ *Sales of mechanical coal stokers for the first six months of this year showed an increase of 93 per cent over the same period in 1935, according to figures released by the United States Bureau of the Census, reports the Committee of Ten. . . . One hundred and eight manufacturers of stokers, representing approximately 91 per cent of the total value of the industry, reported total sales to the Bureau for the first half of 1936 of 19,763 units as compared with 10,233 units for a like period in 1935. . . . Henry T. Cole, president for many years of the United States Radiator Corp., Detroit, has been elected chairman of the board of the corporation. . . . Elwood S. White is the new president. . . . Leaving Lakehurst, N. J., one Sunday last month, the Airship Hindenburg carried the largest commercial freight shipment ever made to Europe by air, a complete oil burning home heating unit shipped by National Air Conditioning, Inc., of New York. . . . 50,000 visited The Peoples Gas Light and Coke Co.'s "open house" and heating and air conditioning show in Chicago during the first two weeks after the opening.*

■ Some $395,882,687 of private capital was invested in the rehabilitation of privately owned property under a guarantee against loss of the Federal Housing Administration from August, 1934, through June, 1936, according to an analysis of the insured loans completed last month by the FHA; this involved 1,086,423 loans. . . . The type of property improved and the number of loans and the dollar volume in each classification are: Single family residential—708,403 loans, total $211,180,696; multiple residential—208,928 loans, $67,031,342; retail store and service trades—80,163 loans, $55,719,417; commercial other than retail—14,431 loans, $16,621,644, farm property—39,943 loans, $14,930,297; institutional—4,224 loans, $3,351,139; industrial 6,529 loans, $14,859,074; unclassified property 23,802 loans, $12,189,078.

■ *Three new super-trawlers for the 40-Fathom Fisheries Co. have many unusual features, according to the "Industrial Bulletin" of Arthur D. Little, Inc. . . . Of particular note is the specially refrigerated hold, cork insulated and fitted with a unique refrigerating system, said to offer interesting possibilities for other applications. The holds will be maintained at a uniform winter temperature by circulating cold air between the hull and the shell of the fish hold. In this way, the average 60 ton load of ice usually carried by trawlers may be replaced by extra tonnage of fish.*

■ Grover C. Dillman was inaugurated as president of the Michigan College of Mining and Technology, Houghton, Mich., August 6, and immediately afterward the honorary degree of Doctor of Engineering was conferred upon him and upon N. S. Osborne, National Bureau of Standards physicist and alumnus of the college, who is widely known for his contributions to steam tables. In his inaugural address, Dr. Dillman stressed the extension of the college's research program, which has yielded many scientific and engineering papers, including those on corrosion in heating systems by Prof. R. R. Seeber and his colleagues. . . . Evening courses in air conditioning, ventilating and heating will be offered by the Polytechnic Institute of Brooklyn, New York, Prof. E. F. Church, Jr., announced last month, heating and ventilating the first semester, and air conditioning the second. Registration may be made during the week of September 18. . . . Both courses will be presented by John James. . . . Prof. George M. Allen of Columbia School of Architecture, New York City, has announced evening courses in air conditioning and acoustics which will be launched this fall. . . . R. W. Waterfill of Buensod-Stacey Air Conditioning, Inc., will direct one air conditioning course, C. A. Bulkeley, chief engineer of Niagara Blower Co., another, and the work in acoustics will be under the direction of V. A. Schlenker, former research engineer with the Bell Telephone Laboratories.

■ *About half an hour before employees leave the newly air conditioned headquarters building of the Brown Shoe Co., St. Louis, the cooling equipment is shut down to permit inside temperatures to become somewhat equalized with outdoor conditions to avoid "heat shock." . . . One of the most elaborate exhibits for the World Power Conference to be held in Washington, D. C., this month is the U. S. Army Engineers' model of the Bonneville Dam, complete even down to the elaborate set of ladders, locks and bypasses built to accommodate the Columbia River salman, enable them to get around the dam. . . . In a recently air conditioned department store, temperatures in the fur department were lowered to nearly 60 degrees. . . . Although employees shivered, sales soared, it is reported. . . . Because the Reuter Seed Co. of New Orleans found that seeds stored in an air conditioned room maintained a much higher state of germination than previously, they recently doubled their air conditioned storage facilities, according to Westinghouse, whose equipment is used. . . . Many store owners feel that it is essential to keep doors open to attract customers. Several air conditioned stores have solved the problem by installing screen doors with double layers of screening between which is placed clear cellophane.*

WHEN THE JOB IS 100% *Republic*

• When the meat processing plant shown above was erected in Cincinnati, Ohio, the builders exercised sound judgment in their selection of pipe and sheet metal. They turned to Republic for both products, thus insuring uniformly high quality and dependability throughout the piping system and the sheet metal work.

Toncan Iron Pipe and Sheets—made of an alloy of refined open-hearth iron, copper and molybdenum with the highest degree of rust-resistance of any ferrous material in its price class—were used for heating and processing lines and for ventilating ducts. Republic Steel Pipe was also used in the piping system.

Through centralizing these purchases, the builders obtained delivery at one time, they received but one invoice and the heating, piping and ventilation systems were backed by the reputation of a reliable manufacturer.

You, too, can insure quality throughout your jobs and at the same time show economies by using Republic Steel products wherever possible. Write for full information.

VISIT THE REPUBLIC EXHIBIT AT THE GREAT LAKES EXPOSITION, CLEVELAND, OHIO, JUNE 27—OCT. 4.

Republic produces a sheet for every degree of corrosion resistance—plain carbon steel, copper bearing steel, copper bearing iron, Toncan Copper Molybdenum Iron and Enduro Stainless Steel. Also butt weld, lap weld and electric weld pipe, made of carbon steel, copper bearing steel and Toncan Copper Molybdenum Iron.

REPUBLIC STEEL

Republic Steel CORPORATION

GENERAL OFFICES · CLEVELAND, OHIO

When writing Republic Steel Corporation for further information, please address Department HP.

Heating · Piping and Air Conditioning

Design, Installation
Operation, Maintenance
in Industry and Large Buildings

BOARD OF CONSULTING & CONTRIBUTING EDITORS

A. R. Acheson, A. Beaurrienne, Sabin Crocker, R. C. Doremus, Philip Drinker, E. L. Ellingwood, Walter L. Fleisher, John F. Hale, William A. Hanley, L. A. Harding, J. J. Harman, R. S. Hawley, E. P. Heckel, J. C. Hornung, John Howatt, Lee P. Hynes, David J. Jones, Alfred Kellogg, C. W. Kimball, Dwight D. Kimball, Charles S. Leopold, Samuel R. Lewis, Homer R. Linn, Frederick D. Mensing, Edgar S. Miller, A. W. Moulder, H. C. Murphy, Alfred J. Offner, A. K. Ohmes, James C. Peebles, F. B. Rowley, R. P. Schoenijahn, F. L. Snyder, T. S. Tenney, R. D. Touton, W. H. Wilson.

EDITOR
Chas. E. Price

ENGINEERING EDITOR
C. M. Burnam, Jr.

ADVERTISING STAFF

W. J. Osborn, R. Payne Wettstein, R. A. Jack
J. H. Tinkham

Published monthly by the Keeney Publishing Company, 6 N. Michigan Ave., Chicago. Telephone: State 6916/ F. P. Keeney, President; W. J. Osborn, Vice-President; R. Payne Wettstein, Secretary; Chas. E. Price, Treasurer/ Address all correspondence to Chicago office/ New York office, Room 1950, Grand Central Terminal Bldg. Telephone: Murray Hill 2-8293/ Cleveland office, 2047 Rossmoor Road. Telephone: Yellowstone 1540/ Los Angeles office, 1406 S. Grand Ave. Telephone: Richmond 6191/ Subscriptions: U. S. and possessions, Canada, Mexico, Central America, South America, $2.00 per year; other, $4.00. Current copies, U. S. and possessions, 25c each, back copies 50c each. January, 1936, issue, $1.00 per copy/ Member of Audit Bureau of Circulations/ Member of The Associated Business Papers, Inc./

Copyright, 1936, by the Keeney Publishing Company

CONTENTS *for* SEPTEMBER, 1936

Vol. 8, No. 9 Pp. 469-530

Heating and Ventilation of a Modern High School Building, by Robert P. Schoenijahn 469

Air Outlet Fixture Adapts Existing Ventilating Ducts to Conditioned Air Distribution 474

How to Design Steam Piping for Maximum Capacity and High Pressure Drop, by Max W. Benjamin 475

1200 Tons Refrigeration Required for Air Conditioning Kansas City Auditorium, by William L. Cassell 479

Pressure Losses in Rectangular Elbows—Part 3, by R. D. Madison and J. R. Parker 483

Welding Lead Sheets and Pipe, by F. E. Rogers 487

Air Conditioning Makes Severe Demands on Water Supply and Disposal Systems 491

Place Air Intake to Avoid Pulling in Dust, by J. M. Pettingell 494

Apartment House in London Completely Air Conditioned, by J. W. Harvey 495

The War on Noise, by Vern O. Knudsen 497

What the Operating Force Must Know for Effective, Efficient Air Conditioning, by Rush D. Touton 500

Air Conditioning for Health—Air Conditioning Gaining Acceptance by Medical Profession, by C. P. Yaglou 502

Controls—Reference Sheet 1, by C. L. Ringquist 504

Book Reviews (back section) 112

Booklets, Reports and Papers (back section) 112

Conventions and Expositions (back section) 116

Equipment Developments (back section) 116

Recent Trade Literature (back section) 132

Index to Advertisers (back section) 138

Journal Section of the American Society of Heating and Ventilating Engineers

The Specific Characteristics of Fans, by M. C. Stuart and J. B. Lusk 507

Performance Test of an Electric Hot Water Heating Boiler, by John James 512

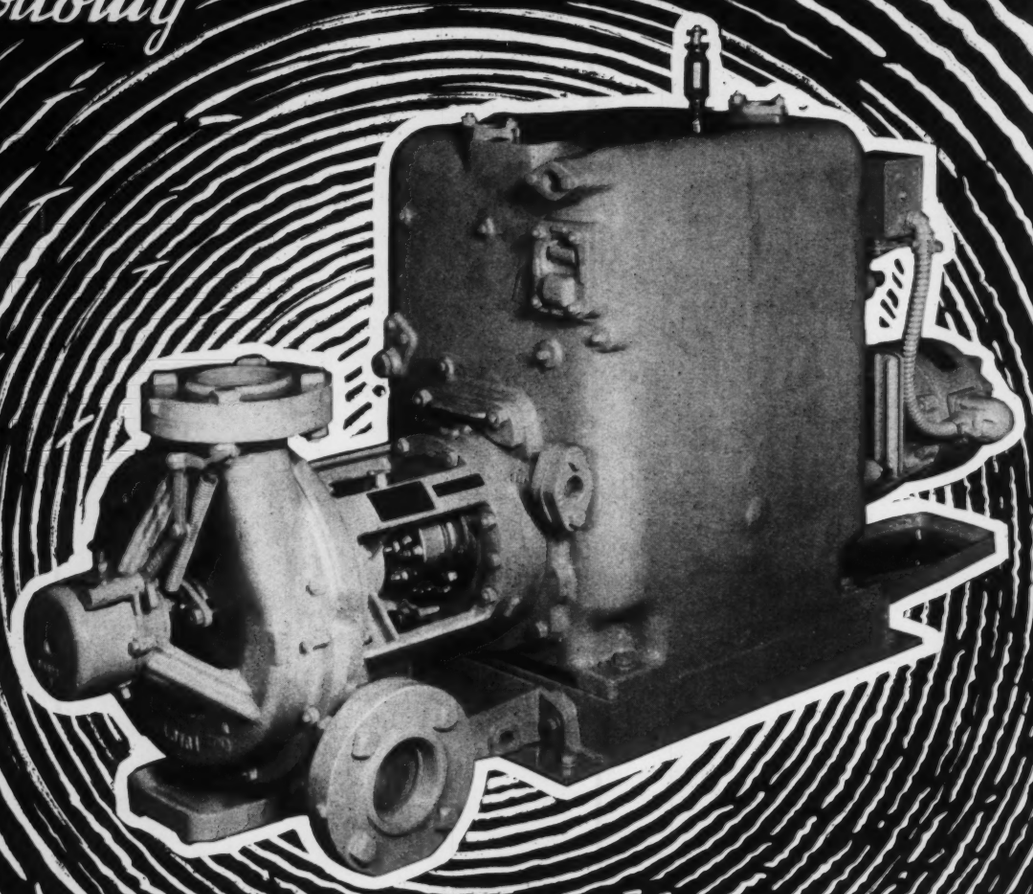
Buffalo Adopts Comfort Air Conditioning Standards 519

A Bigger Program to Meet Research Needs 522

Study Courses in Heating, Ventilating and Air Conditioning .. 524

Bulletin Section 527

Centralized Heating Economy



A RETURN LINE VACUUM PUMP THAT CUTS HEATING COST.

This unusual pump needs no electric current, cutting out greatest item of pump operating expense.

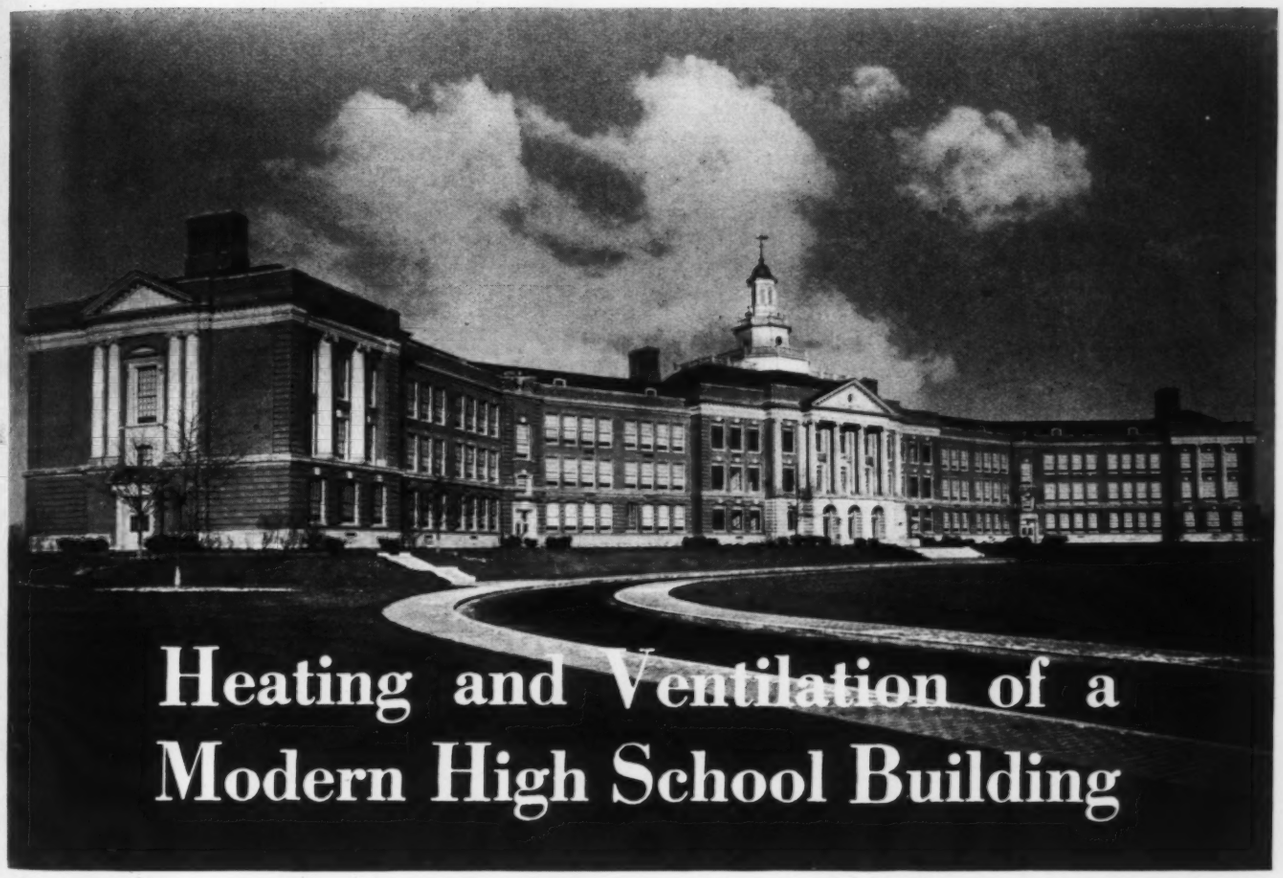
More important, this pump insures absolutely uniform circulation in system. That means continuous steam economy.

Simple, compact, one moving element, no wearing parts, no internal lubrication. Bulletin No. 203 gives the facts. Your copy is waiting.

THE NASH ENGINEERING COMPANY
SOUTH NORWALK, CONNECTICUT, U. S. A.

Heating · Piping and Air Conditioning

Vol. 8, No. 9 • *September, 1936*



Heating and Ventilation of a Modern High School Building

By Robert P. Schoenijahn*

SOME years ago a group of public spirited Delaware citizens recognized the need for improved educational facilities within the state and instituted a survey to present to the public a program for a unified educational system and a plan to finance replacement of obsolete school buildings. In due time a definite program was put into effect, and throughout the cities, townships and counties there grew a new order of educational ideals and a demand for the abandonment of the older structures.

While such an undertaking can never be recorded as completed, another milestone in its development was marked by the erection of the Pierre S. duPont High School in Wilmington, completed and occupied last fall. The building of this modern high school was made possible by an appropriation of the state legislature, supplemented by a PWA grant, making available nearly $2,000,000 for the purchase of a site, the construction and equipment of the building, and the complete development of the grounds.

This beautiful structure was designed by E. William Martin, Registered Architect of Wilmington. It is of

*Consulting Engineer, Wilmington, Dela. Member of Board of Consulting and Contributing Editors.

Completion of Wilmington's Pierre S. duPont High School marked a milestone in the progress of the school development program inaugurated some years ago by a group of Delaware citizens who, recognizing the need of improved educational facilities within the state, instituted a plan for a unified school system and the financing and replacement of obsolete buildings . . . . Incorporating mechanical features representing recent practice, some of which are unique in application, this story of the job by the consulting engineer is more than straight description, includes many ideas and suggestions

Georgian design, laid out in modified "E" formation, the main portion being three stories in height, with a usable portion of the basement at grade. The building is planned for an ultimate capacity of 2200 students and represents a most complete study of local needs. The structure is complete in every detail, fitted with excellent equipment. The site embraces a plot of about twenty acres near the northerly limits of the city and has been completely developed with athletic arena, play fields, parking spaces, landscaping, new streets and walks.

The mechanical features are set forth in some 250 pages of specifications and are portrayed by some 29 sheets of drawings illustrating the ventilating and heating systems and the plumbing and electrical work. As all of these so-called "mechanical" trades are interrelated, one section of the work cannot be described without some reference to the others. Most careful study was required to produce a well co-ordinated design that would permit all parts of these trades to be installed harmoniously, so that each and every part would fit into an intricate structure.

The design of the mechanical equipment for any school building can scarcely be entirely original, but usually exploits the modern trend best suited to the needs of the community, influenced by traditional practice; yet it should express the technique and experience of the designing engineer. A description of the ventilating and heating system as applied to the Pierre S. du-Pont school may therefore be of interest as there are features representing recent practice, some of which are unique in application.

Boilers Are Stoker Fired

In the course of the development of the building plans, the boiler plant gravitated quite naturally toward the physical center of the unit, being placed below the cafeteria and kitchen wing, with the boiler room floor about 23 ft below grade. Considerable saving in excavation was effected by placing the coal vault at an elevation 8 ft higher than boiler room floor, thus permitting fuel to be discharged from this upper level into the top of the stoker hoppers. The available fuel storage is about 450 tons based on an average depth of 8 ft. Entrances to the boiler room are from an outside stairway and from the basement corridor with steel stairway from which leads a suspended runway to gain access to the main control valves for the heating and plumbing supply mains.

The boiler plant includes three specially designed steel fire box type, stoker equipped boilers, each having a rating of 29,000 sq ft E.D.R. based on the *Steel Heating Boiler Institute* code, with enlarged fire box providing 150 cu ft of combustion chamber. To insure long life the boilers are constructed with plates suitable for 100 lb steam working pressure, though in other respects they are designed for low pressure (15 lb) in accordance with the *A.S.M.E.* boiler code. The combustion chamber is designed to permit the stoker to develop 125 per cent of normal rating without emitting smoke. The boilers are set on brick wall foundations with steel plate base and brick lined ashpits.

Each boiler is equipped with a heavy duty motor driven underfeed mechanical stoker arranged with variable speed mechanism for fuel and air control, driven

by three phase constant speed motors. Each stoker is connected with an electrical combustion control system actuating the main draft damper, the fuel feed and the air supply control mechanism, thus co-ordinating the three fundamentals for efficient combustion, maintaining uniform steam pressure and a balanced draft condition without hunting. The stoker motor controls are provided with adequate protection for no voltage and overload, interlocked with an electric low water cut-out switch on the automatic water feeder.

To aid efficient operation without unnecessary labor, each boiler is equipped with a soot blower system with central air compressor. This equipment permits thorough easy cleaning of tube surfaces and is used daily. Special cleaning equipment connected to the central vacuum cleaning system for the school is provided to remove soot and fly ash from the boiler, breeching and base of chimney.

The boilers are connected to a steam header in which are located two special reducing valves used in conjunction with two vapor turbine driven vacuum pump units of the heating system. These units, each with a rating of 30,000 sq ft E.D.R., are each equipped with a cast iron receiver tank and two condensate vacuum pumps, one driven by a low pressure steam turbine on 2½ lb steam pressure differential, used for normal operation; the other pump is electrically driven, fitted with automatic control to start the motor if the turbine driven pump should stop for any reason. The turbines consume only 1800 lb per hr of steam utilizing but 10 per cent of energy input, the balance being passed into heating system. A minimum of 1,000 lb per hr of steam is required to operate the turbine; hence if the heating load (radiation and main losses) is less than 4000 sq ft demand, the electrical end of the vacuum pump unit automatically comes into operation. During normal conditions the vacuum pumps operate without cost for electric current, the turbines acting as a reducing valve, while steam required in excess of the turbine demand is automatically bypassed through the two specially designed butterfly reducing valves in the main header. The boilers are operated to maintain steam pressure of about 5 lb gauge; this results in a uniform pressure of 2 to 2½ lb in the two steam heating distribution headers.

TOP TO BOTTOM

The boiler plant comprises three stoker fired steel fire box boilers, each rated at 29,000 sq ft E.D.R. View shows stoker hoppers which are filled from loading platform. . . . Class rooms are equipped with ventilating heater units and supplementary direct radiation, all connected with pneumatic temperature control system. View shows ventilating heater unit with front and end covers removed. . . . Class rooms are provided with gravity vent outlet at floor with connection to horizontal trunk ducts above hung ceiling of corridor, which lead into vent tower in attic. . . . Locker and shower room exhaust systems, where moisture laden air is removed, are provided with duct work of sheet copper and exhaust grilles of aluminum. . . . 48 in. x 120 in. hot water generators equipped to heat 500 gal per hr each from 50 to 180 F with steam at 2 lb ga

Layout of Steam Mains

The heating system consists of a low pressure vacuum system supplying steam at about 2 lb initial pressure to radiation and maintaining a vacuum of about 7 in. of mercury on the return header at the vacuum pumps. The system of steam distribution provides for separately valved mains; two serving upfeed risers to overhead mains in the attic, with downfeed supply for each vertical group of class rooms. These supplies are installed as a continuous loop entering and leaving vertical chases in the outside walls, with only the horizontal portion of the loop exposed at the ceilings of rooms. Corresponding return mains are carried parallel with the steam supply and as both are graded in the same direction, the exposed piping is less conspicuous than the conventional design with horizontal steam and return runouts from risers graded in opposite directions.

Certain parts of the building have separate steam supply with overhead mains in basement and downfeed supplies to drip points. These mains serve the two gymnasium wings, the cafeteria and the auditorium, so these sections of the building may be used separately at night, while the mains to class rooms can be cut off. It is to be noted that radiation in vestibules and corridors leading to each section is connected to the corresponding steam mains serving that section of building.

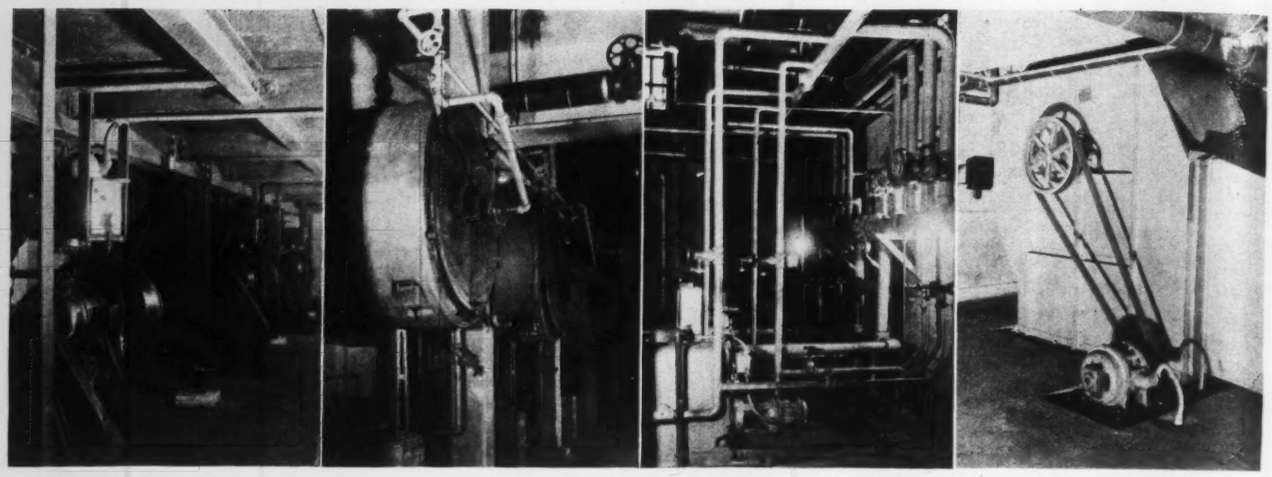
Each system of steam distribution is provided with a corresponding return main continued separately back to the boiler room, and is there provided with a stop and drain valve at the connection to the return headers at the vacuum pump units.

In general, all steam supply and return piping is installed with welded construction using forged welding fittings on pipe sizes down to and including 1½ in. Welding fittings with threaded outlets are used for all branch runouts 1¼ in. and smaller. Branch runouts to radiation where 1¼ in. or smaller are made up with threaded pipe and screwed cast iron fittings. The welded pipe construction was adopted to guard against possible leaks as much of this work is above plaster ceilings and concealed in walls and partitions. A rigid specification for welding was adopted and all work was carefully inspected and tested before covering was applied or pipes concealed.

All steam mains are standard weight steel pipe, the return piping being genuine wrought iron pipe. All pipe work was tested to 100 lb gauge by filling with water which was used to wash out the system, and again tested with steam at 10 lb gauge with trap interiors removed during the period of temporary heating, thus guarding against possible leakage from expansion and contraction.

In general all piping is insulated with 85 per cent sectional magnesia covering, except horizontal runouts at class room ceilings and return mains in basement. Within the unfinished rooms and pipe spaces the covering is painted with two coats of emulsified asphaltum, while in finished rooms, covering and exposed pipe work is painted with three coats of special oil paint. Piping systems are identified by dip painting the covering bands in enamel of different colors. This is very serviceable and permits uniform color to be applied to covering and pipe work.

The traps are constructed with monel metal interiors, including bellows, valve pin and seats which are removable. Drip points in the steam system are terminated with a special cast iron drip fitting having valve, strainer



LEFT TO RIGHT

The boilers, equipped with motor driven underfeed stokers capable of producing 125 per cent rating. Each stoker unit is fitted with an electric combustion control shown supported from underside of coal loading platform. . . . Each boiler is fitted with a soot blower with special control valve, all located on rear combustion doors. These are used daily to clean heating surface and maintain high efficiency. . . . The several steam distribution mains have corresponding vacuum return mains carried back to headers at the vacuum pump. Each return has separate stop and drain valve to visible discharge to facilitate detecting trouble in any section. . . . The 25,000 cfm auditorium fan, driven by a 7½ hp motor through V-belts

and float type trap with thermostatic air vent connecting into vacuum return lines.

Hot Water Service

Hot water for domestic use is a considerable factor in a building containing so many showers, a large cafeteria, domestic science departments and many lavatories and sinks. To provide an unfailing source of hot water supply the specifications provided each heating boiler to be equipped with an external submerged coil type indirect hot water heater having a capacity to heat 800 gal per hr of water through 100 deg rise with water in the boiler at 212 deg. These heaters are cross connected by copper circulating lines to two 1,000 gal hot water storage tanks which are also equipped with removable manifold type steam heating coils each having capacity to heat 500 gal per hr from 50 to 180 F when supplied with steam at 2 lb gauge. The combination of the indirect heaters and steam heating coils is used when the heating boilers are in service; at other times hot water is generated by a separate hand fired steam boiler connected to the heating coils in storage tanks. This provides three methods of generating hot water for domestic requirements.

Unit Ventilators and Their Control

Typical class rooms are equipped with a heating and ventilating unit of the semi-recessed type projecting only 8 in. in the room, contained in a neatly designed enclosure with duco enamel finish and stainless steel trim. Supplementary direct cast iron radiation is installed in conjunction with the units.

Each room is equipped with pneumatic temperature control designed to deliver full heating output of both unit and direct radiator during the heating up period. When the room reaches 67 F the thermostat cuts off the direct radiator and opens the outside air damper in the unit to admit a minimum of ⅓ outdoor air with steam on heating element of unit until the room temperature reaches 70 F, when all steam is shut off at the unit. With any increase in temperature above 70 F the damper opens to increase the quantity of outdoor air and reduce recirculated air. A leak-stat located above the unit heating element prevents the air stream from the unit entering the room below 60 F. This method of control compensates for body heat of occupants and sun effect; at times the unit may be delivering all outdoor air even in very cold weather with a room fully occupied and the sun shining on windows.

Experience indicates that satisfactory relative humidity is maintained due to the proportioning method of controlling the mixture of outdoor and recirculated air. The rooms are remarkably free from odors. Former requirements governing the installation of heating and ventilating units made it mandatory to supply all outdoor air during school occupancy. The type of units and system of temperature control installed effects a substantial saving in fuel and has justified the rejection of the old criteria of 30 cfm of outdoor air per pupil at all times.

All classrooms are arranged with gravity exhaust outlet at the floor connected by sheet metal duct leading into collecting ducts within corridor ceilings; these continue separately to main ducts in attic, there connect to a central chamber in the vent tower. Pneumatically operated louvre dampers are built into the tower duct; these are closed to prevent loss of heat from the building when school is not in session. The operation of the ventilating heater units and gravity vent dampers is automatically controlled as described later.

In general all corridors, stairways, toilet rooms and other spaces not used for classes or assembly are heated by direct radiators fitted with self-contained temperature control valves which function with reasonable accuracy and effect a substantial saving in fuel.

Heating and ventilating units also heat the main entrance and lobby, the gymnasiums, the cafeteria and certain special rooms; all are fitted with the same system of pneumatic temperature control.

Two Large Gymnasiums

It is of interest to note the facilities devoted to the physical development and health of pupils; there are two large gymnasiums, one for boys and one for girls; and separate corrective health rooms equipped for the care of pupils with physical defects.

The auditorium is a most attractive room with limestone wainscot, acoustical sound treatment and fully equipped stage having standard theatrical overhead grid for drops and scenery, thyratron dimmer control for stage lighting effects, complete motion picture and sound equipment, radio with remote control, amplifiers and microphones. This room is provided with a separate heating and ventilating system comprising a central fan room with primary and secondary heaters, outdoor air duct, automatic air filters and complete automatic temperature control. The mushroom system of air distribution was adopted, delivering tempered air under seats; supplementary concealed radiation is installed to deliver heated air at window sills to prevent local down-drafts. Gravity exhaust is provided for removal of vitiated air, grilles being placed under the balcony and in the main ceiling, all connected by sheet metal ducts to roof ventilators fitted with pneumatically actuated dampers. Air distribution is balanced to produce uniform temperature conditions at any location on the main floor or in the balcony. For quick heating of this large room, provision is made to recirculate air through the fan system. The main ducts from the air supply fan are lined with rubber impregnated acoustical hair felt which completely eliminates transmission of fan or air noise. The concealed direct radiation is sufficient to maintain 50 F room temperature in zero weather when the fan system may not be in service.

Program Clock Control Cuts Electrical Demand

At this point it may be well to describe a rather unique feature in the application of a program clock system to control automatically the operation of the heating and ventilating system. This feature was adopted to bring into service at the proper time the various systems which are usually started manually by the fireman or janitor. All circuits for motor driven apparatus and air lines for damper control originate in the switchboard room off the boiler room, where a drum type program clock is installed with selective contacts which automatically throw on and off the various electrical circuits through magnetic contactor switches and operate electro-magnetic air switches in air lines to main dampers in gravity vent systems. As an example of the operation, the ventilating heater units in rooms are started at a predetermined time for heating the building in the morning, those along the north side starting first, then west, east, and finally the south side, each at an interval of several minutes. This eliminates sudden electrical peak loads and permits the gradual building-up of steam demand on the boilers. About 15 minutes before the first class period, the clock actuates the circuits operating the fan motors of the several toilet room exhaust systems and opens all gravity vent dampers. At the closing hour of school the clock causes the reverse sequence to take place. The clock program is set up for the entire year including regular school days, Saturdays, Sundays and holidays, month by month. Provision for emergency operation is made by means of manual switches to bypass the clock program for each circuit, which meets the condition for special classes or meetings at night or on non-school days. However, should the attendant fail to stop any equipment which has been manually started, the program clock will automatically cut it out of service after 11 p. m. and then re-set the circuit for automatic clock control for the next morning operating cycle.

A further use of this program clock is to prevent the operation of certain large motor driven equipment, such as the 25 hp vacuum cleaning system motor, until such time as other motors are off the line. This automatically reduces peak electrical demands and effects a substantial saving in the demand charges for electrical service.

This program clock is also connected to operate the automatic flushing system for urinals. The water supply mains to various toilet rooms are zoned and the branch lines to various groups of urinals are fitted with pneumatically actuated flush valves controlled by electro-pneumatic switches which are operated at 15 minute intervals during school hours and at longer periods after school. Any timing is possible from 5 minutes up.

Summary of Equipment

Boiler Plant:

Three 29,000 sq ft E.D.R. steel boilers.
Two 30,000 sq ft duplex turbo-electric vacuum pumps.
Three electric driven underfeed stokers.
Combustion control for each stoker.
One 4170 sq ft steam fire box boiler for auxiliary hot water heating.
Boiler soot blower system.

Heating System:

Two pipe steam-vacuum

Total connected heating demand (less main losses)	57,000 sq ft E.D.R.
Cast iron radiation	13,286 sq ft E.D.R.
Copper convectors	6,994 sq ft E.D.R.
Seventy-six ventilating class room heater units	13,376 sq ft
Sixteen special ventilating heater units	15,668 sq ft
Indirect radiation for auditorium	1,272 sq ft E.D.R.
Hot water heating demand	5,800 sq ft E.D.R.

Ventilating System:

Auditorium fan, 25,000 cfm, 338 rpm.
Motor, 7½ hp, 208 volt, 3 phase, 60 cycle with V-belt drive.
Air filters, automatic motor driven type.

Exhaust Ventilating Systems:

Eleven multivane fan exhaust systems removing a total of	33,220 cfm
Three propeller fan exhaust systems removing a total of	3,600 cfm
Three power roof ventilating exhaust systems removing a total of	2,240 cfm
Two chemical exhaust systems removing a total of	900 cfm
Total air removed by fan exhaust systems	39,960 cfm

Seventeen Exhaust Systems

There is a total of 17 separate mechanical exhaust systems. Eleven are devoted to ventilation of the general and special toilet rooms, while others are provided for the removal of vitiated air from the general offices and interior private toilet rooms, shower and locker rooms, miscellaneous interior rooms and janitor's closets. These systems are provided with lock type registers to balance the air distribution, the sheet metal ducts leading into the attic space where motor driven exhaust fans are located. The fans are operated by remote control through magnetic contactors, started and stopped by the program clock previously mentioned; a damper operated by an electro-pneumatic switch is placed in the duct connection

at each fan to open on starting of motor and close on stopping. This prevents unnecessary air and heat loss from the building after school hours.

The kitchen has a separate exhaust system, having a stainless steel hood over cooking equipment with a duct leading to the fan on the roof, arranged with automatic damper and fire damper in bypass to a free exhaust, to protect fan in case of fire in hood or duct. Fan is housed in enclosure of 24 oz crimped copper built on an angle iron framework.

There are two separate systems of exhaust in the chemistry rooms for removal of fumes from hoods. Connections from hoods to fans are of duriron with pipe of same material into hood; the discharge ducts from fans are fabricated of acid resisting metal with all welded construction and discharge through vent chimneys. These fans are locally controlled by thermal switch at each group of fume hoods. The interior of hood is built with a false back of transite board with exhaust opening top and bottom and fitted with slide dampers connected by vertical bar to permit adjustment for air removal from bottom or top as required.

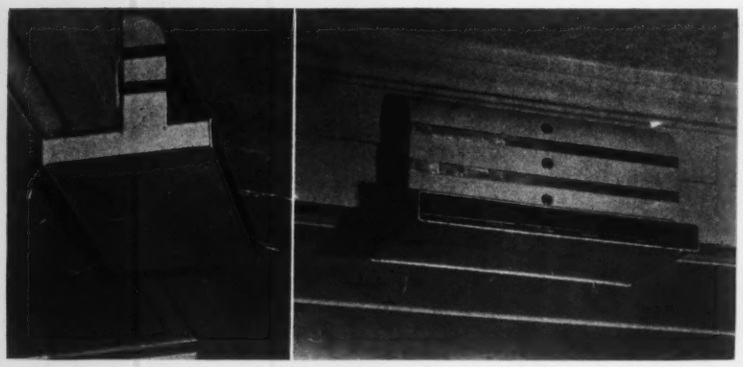
The smaller exhaust fans are direct connected, and the larger units are fitted with V-belt drives. All are mounted on structural steel foundation bases with floating type rubber sound and vibration isolation pads. Connections from fans to ducts are made with heavy oil impregnated canvas collars, except for the kitchen fan which is made up with 1/8 in. thick woven wire asbestos collars.

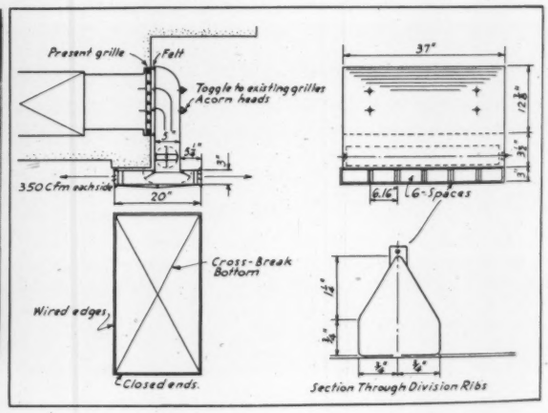
Special care was taken in the planning of cat walks throughout the attic space so each and every fan, damper and valve of piping systems can be easily serviced.

The exhaust systems for the boys' and girls' shower rooms, where considerable moisture is present, are installed with sheet copper ducts connected to registers with polished aluminum grille faces.

The gravity exhaust systems for class rooms as previously noted have sheet metal ducts leading to main collecting ducts in the attic space, exhausting vitiated air through louvres in the main tower of the building. This system was adopted in lieu of venting into the roof space as the roof sheathing is wood and the attic space could not be considered fireproof construction. The building is fully equipped with approved lightning rods protecting the tower and all points of the roof.

Air Outlet Fixture Adapts Existing Ventilating Ducts to Conditioned Air Distribution





Air outlet fixture attached to existing ventilating grille to direct conditioned air toward side walls as well as toward center of auditorium

THE novel air outlet fixture illustrated here was worked out for the silica gel air conditioning system for the home service auditorium in the Peoples Gas, Light & Coke Co.'s building in Chicago.

The auditorium is a large hall two stories in height, along each side of which runs a bay one story high. An existing ventilating duct ran along each side of the hall, immediately above the one story bay, discharging air horizontally toward the center of the auditorium only.

When air conditioning was installed, it was desired to use these existing ducts, but it was deemed necessary for the air to be discharged not only toward the center of the auditorium, but back under the ceilings of the one story bays as well. The outlet illustrated was therefore designed to fit over the existing ventilating grilles, taking the air down just below the ceiling level of the bay and there discharging part of the air toward the center of the auditorium and part into the bay. The fixtures—ten were required—are nicely finished with a bright metal trim and do not in any way mar the appearance of the auditorium.

Careful observations since the air conditioning plant was put into operation indicate very satisfactory air distribution. The auditorium is the scene of the "home comfort show" sponsored by the gas company, at which is exhibited many types of air conditioning and gas fired heating equipment.

How to Design Steam Piping for Maximum Capacity and High Pressure Drop

By Max W. Benjamin*, *with a note by* Sabin Crocker**

AS distinguished from the cases commonly met in the calculation of pressure losses in piping, the writer was recently called upon to solve a steam flow problem which involved the well established but seldom encountered phenomenon of acoustic velocity in the flow of elastic media. While the fundamentals underlying such cases can be found in many books on physics and thermodynamics it is believed that their application to piping problems has not been brought sufficiently to the attention of piping designers. It is the purpose of the present article to point out the limitation which this natural phenomenon imposes on the capacity of a pipe line and to illustrate how it may be dealt with when encountered.

Two Classes of Service Where Acoustic Velocity Limit Occurs

There are at least two classes of service in which the acoustic velocity limit may occur:

(1) Where a large pressure drop is available which may be utilized in selecting the minimum size of line needed for a given capacity.

(2) Where the fluid is flowing at very low pressures so that the pressure loss is quite large relative to the static pressure in the line.

An example of the first case would be a central heating system where a relatively short line feeds a constant pressure steam distribution network from boilers at considerably higher pressure. At partial loads it would be necessary to do some throttling between the boilers and the distribution system but it is conceivable that the pipe size could be so chosen that at full load all the desired pressure loss would occur in the piping itself. An example of the second case would be the exhaust steam piping between a turbine and a condenser situated some distance away. Other examples probably will occur to the reader, depending upon his particular field of experience.

Restricted Application of Usual Formulas

In all formulas for pipe friction the pressure loss for turbulent flow is some function of the quantity of flow raised to about the second power multiplied by the length of the line. For a given pressure loss, therefore, the rate of flow increases as the length of line decreases, and in the extreme the flow would become infinite if the length of line were reduced to zero. Infinite flow would, of course, mean infinite velocity. Actually, with all expansive fluids, such as steam and air, the velocity of flow in a conduit of uniform cross-sectional area cannot exceed the acoustic velocity, which is the velocity of sound in the particular fluid at the pressure condition involved. Furthermore, there must be sufficient available energy between the initial and final pressure to produce the necessary increase in velocity.

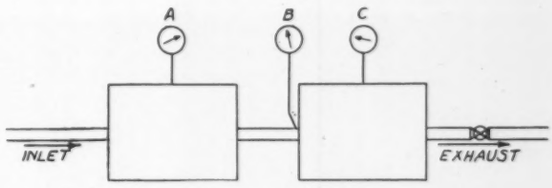


Fig. 1—Illustrating description of behavior of gases and vapors having adiabatic exponent greater than unity

If an experiment be carried out in which steam at high pressure is allowed to flow through a short pipe into a region of lower pressure as illustrated in Fig. 1, the following pressure conditions can be observed. With the valve in the exhaust line closed, gages *A*, *B*, and *C* all indicate the same pressure. When the valve is opened slightly a relatively small flow of steam takes place. Pressure *A* remains constant, but pressures *B* and *C* both fall somewhat and are equa to each other. As the valve is opened to permit still greater flows, pressures *B* and *C* fall still more and again remain equal until a point is reached where their value is about 58 per cent of pressure *A*. As the valve is again opened further, pressure *C* drops still lower but pressure *B* remains at 58 per cent of pressure *A*. Furthermore, if the steam flowing through the apparatus had been condensed and weighed during the experiment it would be found that as the valve is opened more and more from its closed position the rate of flow would increase until pressures *B* and *C* had dropped to 58 per cent of pressure *A*, and that further opening of the valve would not result in any further increase in the rate of flow. If the steam velocity in the short pipe be computed for the maximum flow it will be found equal to the velocity of sound in steam at pressure *B*.

The performance just described is typical of the natural behavior of all gases and vapors which have an "adiabatic exponent" greater than unity. Table 1 gives the adiabatic exponents for a number of gases and vapors. These exponents are used to calculate the

*Engineer, The Detroit Edison Co., Detroit, Mich.
**Engineer, The Detroit Edison Co. Member of Board of Consulting and Contributing Editors.

A short time ago we had occasion to compute the size of the exhaust line required for an emergency steam driven boiler feed pump turbine which on the few occasions it is operated exhausts either to the main unit condenser or to atmosphere. Since considerable pressure drop was available for producing flow to the condenser, we had in mind using as high a steam velocity as possible so as to keep the pipe diameter small. On investigation, however, we found that not all of the available pressure drop could be converted into speed within the ceiling established by the acoustical velocity. In other words, it was necessary to use a larger pipe diameter than called for on a pressure drop basis, merely because the steam could not be made to travel faster than the acoustical velocity.

There are certain instances in piping design where it is possible to take advantage of a large available pressure drop to reduce the size of line required. An example of this is the case of central heating system feeders. Such lines, however, must be designed carefully so as not to reduce the size to an extent which would require velocities in excess of the acoustic velocity for the expected capacity. There are other cases where the acoustic velocity will be obtained irrespective of any practicable size which may be chosen for the installation. Such a case is a steam exhaust line connected to a condenser at very low absolute pressure. The pressure loss will vary with the pipe size, however, and the calculation of the drop is rather different for such a case than for the usual pipe line.

Mr. Benjamin's article calls attention to the limitations of velocity for elastic fluids, and is, I believe, a timely contribution. The example and the graphs help to visualize the effects of acoustic velocity on capacity.—SABIN CROCKER.

acoustic velocity as explained in step 2 of the sample problem given later, and may also be used to determine the ratio of the critical to the initial pressure as

$$\left[\frac{2}{n+1}\right]^{\frac{n}{n-1}}$$

The lower 58 (for steam) per cent of the available pressure drop may be used to obtain velocities higher than the velocity of sound if a divergent section is attached beyond the point where the velocity of sound is attained. It is the nature of these elastic fluids that the specific volume increases faster than the velocity at all velocities above the acoustic. If the conduit is not shaped to provide for this volume expansion, the accelerated increase in volume cannot take place and therefore any increase in velocity beyond the velocity of sound is not possible. It should be noted, too, that the addition of a divergent section does not increase the capacity of the line, but merely permits the utilization of the lower range of pressure drop for the production of additional velocity at a greater specific volume.

The phenomenon described in the imaginary experiment is discussed mathematically in Loewenstein's translation of Stodola's "Steam and Gas Turbines," Vol. I, p. 61, in Emswiler's "Thermodynamics" and in many other text books on physics and thermodynamics. At the Swiss Federal Institute of Technology, Zurich, is a wind tunnel designed for air velocities exceeding the acoustic. Recognition of the fact that velocities exceeding that of sound could not be obtained in a conduit of uniform cross-sectional area led the designers to provide a divergent nozzle ahead of the "super-sound-velocity" section. Steam turbine nozzles very often have a divergent section so as to utilize effectively the available energy of the steam.

In any case of a conduit having uniform size the possibility of acoustic velocity is indicated if the final pressure is less than 58 per cent of the initial pressure for steam, or 53 per cent for air. These are the pressure ratios which denote the critical pressure and hence determine the acoustic velocity in properly proportioned short nozzles. The actual final velocity in a pipe line will depend upon friction losses as well as the available pressure drop. Fig. 2 shows the general relationship between length of line, pressure drop, and weight of flow.

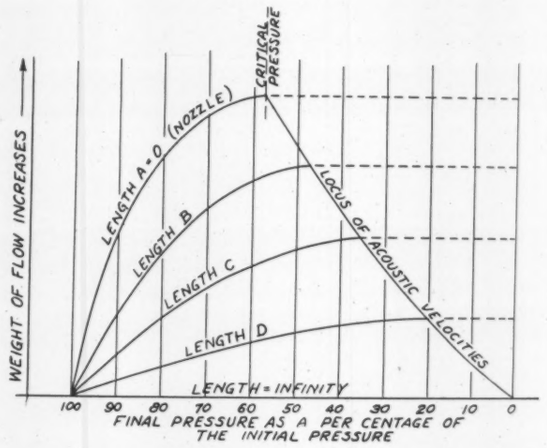

WEIGHT OF FLOW INCREASES
CRITICAL PRESSURE
LENGTH A = 0 (NOZZLE)
LENGTH B
LENGTH C
LENGTH D
LENGTH = INFINITY
LOCUS OF ACOUSTIC VELOCITIES
100 90 80 70 60 50 40 30 20 10 0
FINAL PRESSURE AS A PER CENTAGE OF THE INITIAL PRESSURE

Fig. 2—Diagram showing relationships between pressure drop, length of pipe line, and weight of flow for steam

The length of pipe line increases in the alphabetical order given, that is, length *D* is the longest line shown. It will be noted that in the case of a nozzle the weight of flow does not increase after the final pressure has dropped to the critical pressure which is 58 per cent of the initial pressure. With a finite length of piping, the weight of flow at all final pressures is less than with a nozzle because of friction losses, and the acoustic velocity is not reached until the pressure has dropped below the critical pressure. In any case, however, the weight of flow cannot exceed the weight corresponding to the acoustic velocity. Higher velocities may be obtained by the use of a diverging nozzle or increasing cross-section beyond the point where acoustic velocity occurs, but this of course cannot increase the weight of fluid flowing through the section where the acoustic velocity exists.

Table 1—Adiabatic Exponents for Gases and Vapors

SUBSTANCE	ADIABATIC EXPONENT, *n*
Acetylene	1.28
Air	1.4
Ammonia	1.31
Argon	1.66
Carbon dioxide	1.31
Carbon monoxide	1.41
Ethylene	1.20
Helium	1.66
Hydrochloric acid	1.40
Hydrogen	1.40
Methane	1.32
Methyl chloride	1.20
Nitric oxide	1.40
Nitrogen	1.40
Nitrous oxide	1.26
Oxygen	1.40
Saturated steam	1.13
Sulphur dioxide	1.25
Superheated steam	1.30

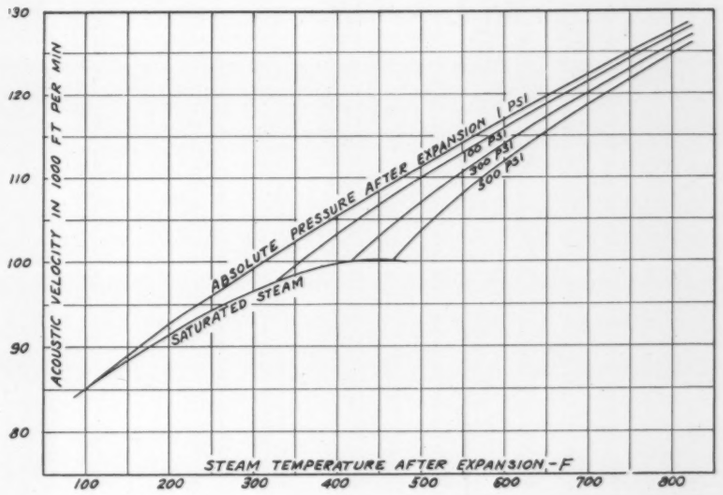


Fig. 4—Approximate values of acoustic velocity for steam

For cases in which the available pressure drop and length of line are known, the flow should be computed in the ordinary way by some suitable formula. The velocity corresponding to the calculated flow and specific volume at the final pressure may then be determined. If this velocity is less than the acoustic velocity the calculated flow probably is as nearly correct as can be computed. On the other hand, if the calculated velocity exceeds the acoustic velocity, the computed flow is too high and the correct flow will be that corresponding to the acoustic velocity. For any set of conditions the acoustic velocity may be computed as shown in step 2 of the outline of procedure given below.

Design of an Exhaust Line

It is thought that the solution of an actual problem for a low pressure exhaust line will help to clarify the foregoing discussion as well as show in detail the procedure necessary for determining the pipe size in this real case.

The piping under consideration connects the exhaust of a small turbine to a surface condenser, Fig. 3. The condenser pressure is known and the equivalent length of pipe line and approximate steam flow are known. It is desired to determine the absolute pressure at the exhaust of the turbine for different sizes of exhaust piping so as to select the most suitable pipe diameter.

With a condenser pressure of 1 in. Hg absolute it is practically certain that the final pressure (that is, at the condenser end) will be less than 58 per cent of the initial pressure (turbine end) since that would make the initial pressure only $1 \div 0.58 = 1.72$ in. Hg abs and would allow only 0.72 in. Hg for friction loss. The procedure then is as follows:

1. Assume a pipe diameter and, from the piping layout, calculate the equivalent length.

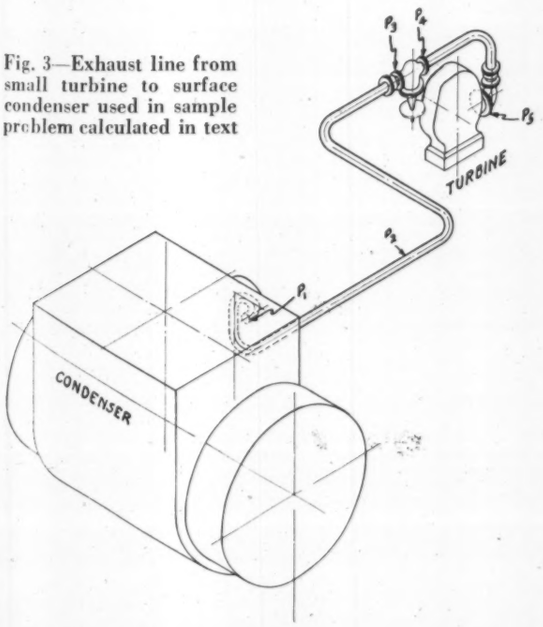


Fig. 3—Exhaust line from small turbine to surface condenser used in sample problem calculated in text

2. Assume an appropriate value of acoustic velocity for first trials or estimate it by means of the formula below, using values of P and V that are thought to be about right. After the final pressure is determined this can be checked by the formula, acoustic velocity in ft per min $= 60\sqrt{gnPV}$, *where* g is gravitational acceleration in ft per sec per sec; n is the adiabatic exponent, which equals about 1.13 for saturated steam and 1.3 for superheated steam; P is the final absolute pressure in lb per sq ft; and V is the specific volume in cu ft per lb at pressure P. Fig. 4 shows approximate values of acoustic velocity for steam.

3. With the approximate rate of flow, pipe size, and velocity known, the specific volume at the pipe end can be computed as,

$$\text{specific volume} = \frac{\text{pipe area} \times \text{acoustic velocity}}{\text{flow in lb per sec} \times 60}$$

4. Determine enthalpy of steam at the pipe end as,

$$\text{enthalpy at turbine exhaust} - \left[\frac{\text{acoustic velocity}}{223.7 \times 60}\right]^2$$

5. From the enthalpy and specific volume determine the absolute pressure by use of the steam tables.

6. With the pressure and specific volume available, check the acoustic velocity assumed in step 2 and if necessary redetermine the specific volume and pressure as in 3, 4, and 5.

7. When a satisfactory estimate of specific volume and pressure at the low pressure end has been obtained these values may be used in a suitable formula for pressure loss, computing pressure losses for short lengths of pipe and proceeding upstream toward the turbine. The specific volume used in the pressure drop formula should be an average value for the particular section of pipe being computed and should be altered in successive trials until the average of the specific volumes at the two ends of the section checks the value used in the formula.

Sample Solution

For the case under consideration the following data are available.

Steam flow = 27,400 lb per hr = 7.61 lb per sec.
Enthalpy at turbine exhaust = 1311.2 Btu per lb.
Condenser pressure = 1 in. Hg abs.
Equivalent length of exhaust piping as follows:

12 in. diam, equivalent length = 322 ft.
14 in. diam, equivalent length = 360 ft.
16 in. diam, equivalent length = 420 ft.
18 in. diam, equivalent length = 480 ft.

The problem is to determine the absolute pressure at the turbine exhaust flange for the different pipe sizes in order to select the most suitable diameter.

The solution for the 12 in. size as outlined above is

(1) Assume 12 in. pipe, 322 ft equivalent length.

(2) Assume acoustic velocity = 108,000 ft per min at the condenser end.

(3) Specific volume $= \dfrac{0.7854 \times 108{,}000}{7.61 \times 60} = 186$ cu ft per lb.

(4) Enthalpy at pipe end

$$= 1311.2 - \left[\frac{108{,}000}{223.7 \times 60}\right]^2 = 1246.5 \text{ Btu per lb.}$$

(5) Pressure corresponding to 186 cu ft per lb and 1246.5 Btu per lb = 2.85 psi abs = p_1.

(6) Check on acoustic velocity assumed in (2)

Acoustic velocity $= 60\sqrt{32.2 \times 1.3 \times 2.85 \times 144 \times 186} =$ 107,400 ft per min.

This is considered a satisfactorily close check on the value of 108,000 assumed in (2) especially in view of the fact that the adiabatic exponent is not exactly constant.

(7) Since this is a rather large line carrying steam at high velocity, Fritzsche's formula for pressure loss should be used. This formula is

$$p = \frac{0.8\, L\, F^{1.85} \times \text{sp vol}}{d^{4.97}}$$

where p is the pressure drop in lb per sq in.
L is the equivalent length of pipe in ft.
F is the steam flow in lb per sec.
d is the inside pipe diameter in inches.

Assume the line to be divided into four lengths of 322/4 = 80.5 ft each.

$$\text{Then } p = \frac{0.8 \times 80.5 \times 7.61^{1.85}}{12.00^{4.97}} \times \text{sp vol}$$

$$= 0.0119 \times \text{sp vol}$$

The specific volume to be used is the average value in each section of the line. By the method of successive trials this is found to be 150 for the section of line nearest the condenser.

Then $p = 0.0119 \times 150 = 1.79$ psi
$p_2 = p_1 + p = 2.85 + 1.79 = 4.64$ psi
Sp vol at $p_2 = 114$

$$\text{Average sp vol} = \frac{186 + 114}{2} = 150$$

For the next section
$p = 0.0119 \times 102 = 1.21$ psi
$p_3 = p_2 + p = 4.64 + 1.21 = 5.85$ psi
Sp vol at $p_3 = 90$

$$\text{Average sp vol} = \frac{114 + 90}{2} = 102$$

For the next section
$p = 0.0119 \times 85 = 1.01$ psi
$p_4 = p_3 + p = 5.85 + 1.01 = 6.86$ psi
Sp vol at $p_4 = 77$

$$\text{Average sp vol} = \frac{90 + 77}{2} = 84$$

For the section nearest the turbine
$p = 0.0119 \times 73 = 0.87$ psi
$p_5 = p_4 + p = 6.86 + 0.87 = 7.73$ psi
Sp vol at $p_5 = 69$

$$\text{Average sp vol} = \frac{77 + 69}{2} = 73$$

The absolute pressure at the turbine exhaust flange therefore is 7.73 psi abs and the vacuum will be $30 - \dfrac{7.73}{0.491} = 14.3$ in. Hg.

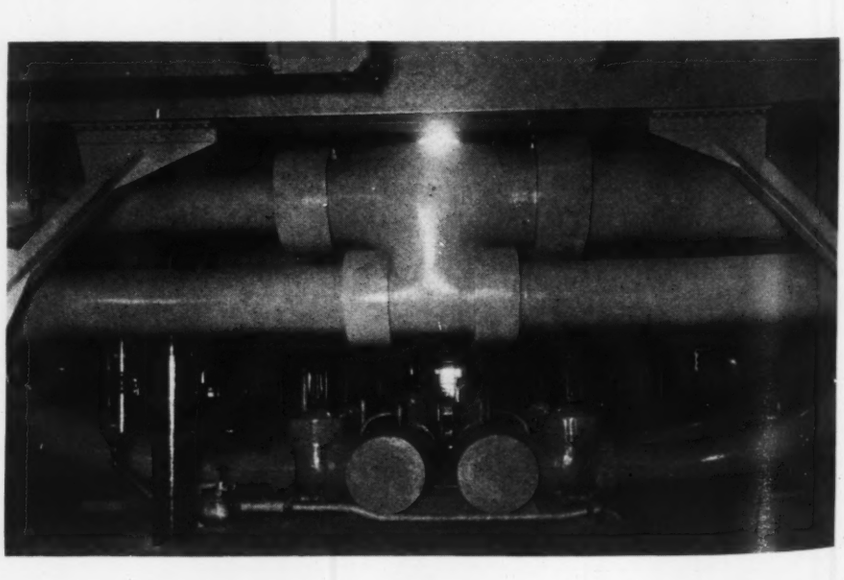
Notice too that the absolute pressure at the condenser end of the line is considerably higher than the pressure in the condenser itself. Similar solutions are completed for the other pipe sizes considered, and for this particular case gave the following results:

Pipe Size In.	Equivalent Length, Ft	Steam Velocity, fpm		Vacuum, In. Hg		
		Turbine End	Condenser End	At Turbine	At Condenser	Inside Condenser
12	322	39,800	107,300	14.3	24.2	29.0
14	360	39,100	107,800	16.9	25.2	29.0
16	420	38,700	106,800	20.1	26.5	29.0
18	480	38,700	106,900	22.3	27.2	29.0

While the vacuum at the turbine improves as the pipe size increases it is interesting to note that the velocities at the two ends of the line remain substantially the same irrespective of size. The reason is, of course, that with lower absolute pressures in the larger lines the specific volumes are greater, with the result that the steam velocity changes but little.

As far as steam carrying capacity is concerned there is no reason why even smaller lines should not be studied for this installation. Other considerations are involved, however, such as the effect of increasing back pressure on the economy of the turbine, etc. In this case the 12 in. size was selected.

While the phenomenon of acoustic velocity will not often be involved in piping design it is important that it be recognized and taken into account wherever it is encountered. A knowledge of this phase of fluid flow may permit the use of smaller lines than would otherwise be selected in some cases, and in any event it will enable the designer to determine the limiting capacity of a given size of line where a large available pressure drop is to be utilized in causing flow.



Pressure reducing station, Beacon Street heating plant

1200 Tons Refrigeration Required for Air Conditioning Kansas City Auditorium

By William L. Cassell*

LIKE the St. Louis municipal auditorium described in the May H. P. & A. C., the new air conditioned municipal auditorium in Kansas City, Mo., is a building of many and varied uses; in fact the auditorium proper occupies less space than do the various committee rooms, exhibition spaces, and theaters.

The architects visualized a building that would house at one time as many different gatherings as practical within the dimensions set up by the space and funds available. With this in mind a building was designed which is 419 ft long, 331½ ft wide, and 153 ft high from the exhibition floor line to the high point of the roof, having a cubage of 16,000,000 cu ft and containing an auditorium, complete theater with two floors of dressing rooms, little theater, exhibition hall, three assembly rooms, and 27 committee rooms of various sizes.

The author adjusts the water supply to one of the air washers for the main auditorium. Exhaust fan is at the left, supply fan at the rear

The auditorium is a room of 5,000,000 cu ft with 97 ft ceiling, having an arena 227 ft long and 128 ft wide, seating 14,000 people without an overhanging balcony. It is air conditioned, equipped with mobile color lighting controlled by a tube type reactor control board which produces various lighting effects, concealed lighting units which give 70 foot-candles of light at the arena floor line, and many other features.

The theater, designed in the modern style, is completely air conditioned, equipped with mobile color lighting controlled from preset tube type reactor control board. The theater seats 2,600 people.

Exhibition space is provided below the main arena and consists of a main floor and balcony. The center portion of the exhibition space has a clear span of 86 ft with 25 ft clear ceilings. It has 90,000 sq ft of usable floor space, is air conditioned, and is equipped with modern concealed lighting, utility outlets conveniently located for various types of power, gas, steam, water, waste, and compressed air.

The small theater will seat 900 people. This room is air conditioned and lighted with specially designed units. There are also two smaller assembly rooms each seating 225 people, one larger assembly room seating 500 and 27 meeting rooms seating from 25 to 250 people each, all of which are ventilated.

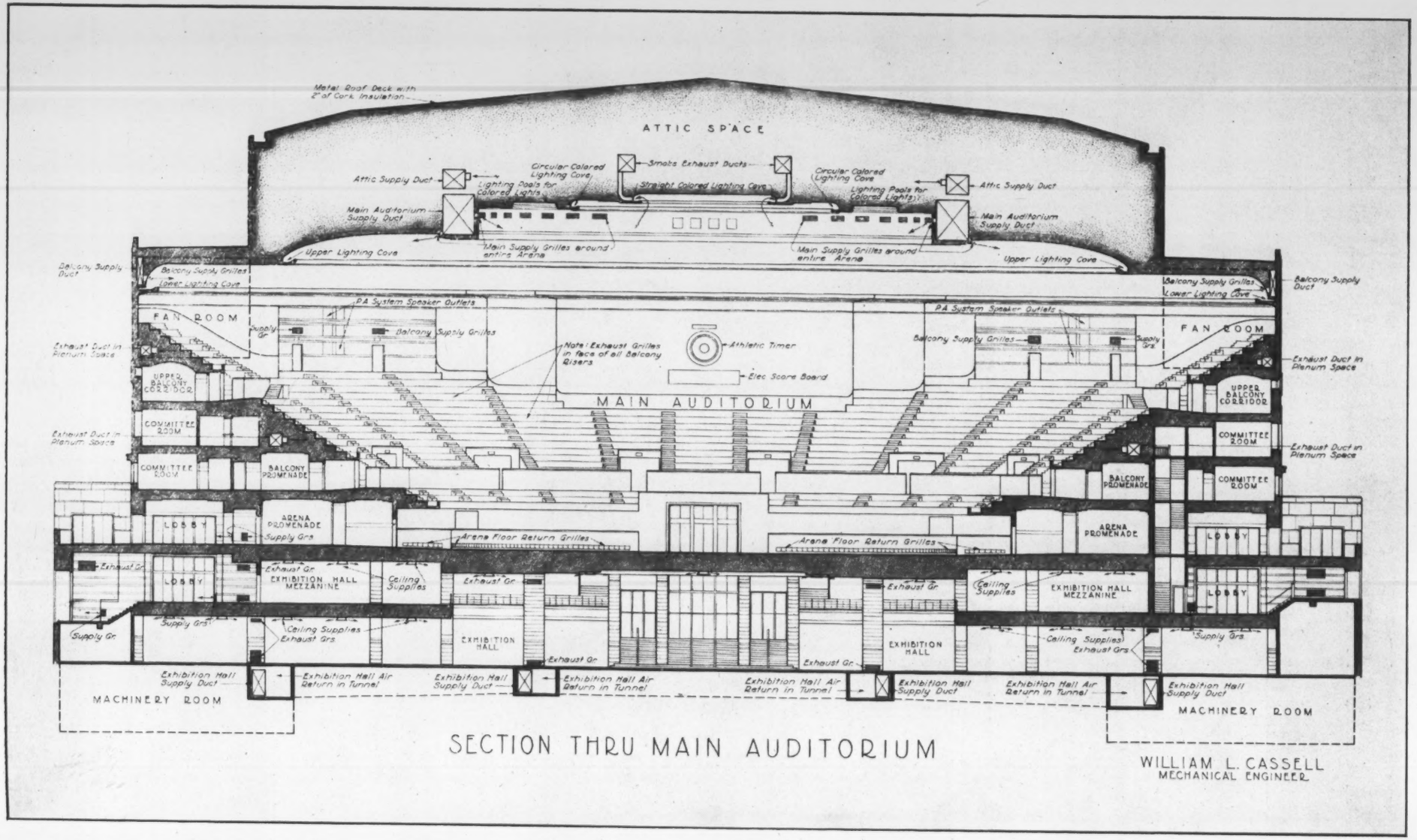
The refrigerating and water cooling equipment for the entire building is situated in two rooms, one on each side of the building near the center in the basement below the exhibition space. In each machinery room are two 300 ton "Freon" four cylinder, single acting compressors connected to shell and tube type water coolers and condensers. Each unit is driven by a 400 hp engine type, 225 rpm synchronous motor direct connected to compressor, making a total of 1200 tons available refrigeration capacity. Water for the condensers is taken directly from the city mains and discharged into the sewer, as the cost of installing, maintaining, and operating cooling towers, as compared to the cost of pumping city water, did not justify the installation of a tower in this instance. Each compressor is equipped with 50 per cent automatic cylinder bypass and 25 per cent hand-controlled cylinder bypass.

One of the 400 hp compressors in each machinery room is equipped with automatic synchronizing units to synchronize the compressors at a definite predetermined mechanical angle.[1] Also, the current limitations on each motor in starting were kept below 300 amperes per second at not more than two second intervals, in order to eliminate flicker in the building lighting system.

Water is pumped through the four water cooling units by four 750 gpm centrifugal pumps to air washers

*Mechanical Engineer, Kansas City, Mo.

[1]See "High Speed Synchronizing Motor Control Insures Minimum Lighting Disturbance," by R. C. Allen, HEATING, PIPING AND AIR CONDITIONING, July, 1936, pp. 370-371 and 377.



Section through main auditorium, showing method of introducing and removing air

situated adjacent to the various conditioned spaces. The water temperature required to hold the auditorium is 40 F leaving temperature with maximum load.

Within the building are 56 supply and exhaust fans handling 1,860,000 cfm of air, driven by a total of 560 motor horsepower. Various smaller rooms have unit ventilators and unit heaters supplying outside air. All entrance lobbies and entrance corridors are heated by variable speed unit heaters, supplying air at the floor line through adjustable deflector grilles across the door openings. This method of heating large entrances has proved very satisfactory. Numerous rooms and outside ramps are heated with concealed cast iron direct radiation.

Control of Temperatures and Air Circulation

The entire building is equipped with a system of pneumatic temperature control. Areas such as corridors, entrances, and toilets, where the temperature is not required to be held at 70 F unless that particular portion of the building is in use are equipped with additional thermostats that will carry the rooms at any predetermined lower temperature desired by changing the control switch in the engineer's room that controls the particular section of the building affected.

It is possible to operate all ventilating equipment without leaving the engineer's office, and at the same time to check the water supply and return temperatures to the various air washer units and the wet and dry bulb temperatures in the conditioned spaces. In the larger rooms several stations are installed so that temperatures can be checked over the entire room. All dampers not automatically controlled—such as on exhaust fans without recirculating connections—are controlled from the board in the engineer's office. All outside air dampers, recirculating dampers, and exhaust dampers are sectionalized so that variable amounts of air may be supplied to the conditioned spaces depending upon the occupancy and outside temperatures.

All fans supplying conditioned spaces are driven by four speed, slip ring, quiet operating, motors mounted on floating cork bases, and all have variable speed control switches and indicating lights in the engineer's room. All fan motors have start and safety stop stations adjacent to the motor.

Air Distribution in Auditorium

Four supply and four exhaust fans situated in four fan rooms, one at each corner of the auditorium near the roof line, handle the auditorium. The recirculated air is taken from the discharge side of the exhaust fans; the outside air is taken in quantities determined by the operator from the control board in the engineer's room. The air is then passed through the heating coils and air washers and delivered to the main duct, which supplies air through ceiling outlet grilles evenly distributed over the entire auditorium with adjustable diffusers so that the direction of the air flow is controlled. The section of the auditorium shown here indicates the method of introducing and removing the air. Each supply fan delivers 110,000 cfm and each exhaust fan handles 90,000 cfm.

The return air is taken from the arena through grilles at the floor line and from mushrooms evenly distributed throughout the entire auditorium. The damper arrangement is such that all return air can be exhausted to the outside or recirculated. The return duct system is designed and equipped with dampers so that 60 per cent of the air can be returned from the arena floor, if this is desirable due to heat loads becoming concentrated because of special displays or exhibits.

All supply ducts and all return ducts outside of cooled spaces are lined with 1 in. board type insulation. All fans, washers, and housings are insulated with 2 in. of cork with canvas jacket.

Smoke Exhaust

At the highest point in the center portion of the auditorium ceiling, smoke exhaust outlets are installed back of the lighting coves and connected to a system of ducts in the attic space, to which a 50,000 cfm four speed exhaust fan is connected to exhaust the smoke to the outside.

Exhausting Heat from Lighting

The arena floor is lighted with 112, 1500 watt floodlight projectors mounted above the ceiling; the entire ceiling is lighted with a system of cove lights, the center portion of which is in four colors, the outer two coves being white light only. The connected load of the cove lights is over 200 kilowatts. The larger part of the heat generated by the cove lights and arena floodlights is taken directly out of the attic space over the arena by a system of supply and exhaust fans and duct work, exhausting and supplying air evenly throughout the entire attic space over the arena, preventing the heat from being picked up by the conditioned air.

Air Washers and Control

The four auditorium air washers are of the double bank spray type with complete set of eliminators in front of each bank of sprays. Each washer is designed to handle a maximum of 750 gpm of water with 376 nozzles at 50 ft head.

The air is controlled during the cooling season by dampers, which either bypass the washer or pass the air through the washer. The dampers in each system are controlled by a two-bulb, remote adjusting type thermostat with one bulb located in the return duct system and one bulb in the outside air intake. The thermostat compensates for the outside temperature and will hold a lower temperature on a 100 F day than on an 80 F day, the variation depending upon the setting of the instrument.

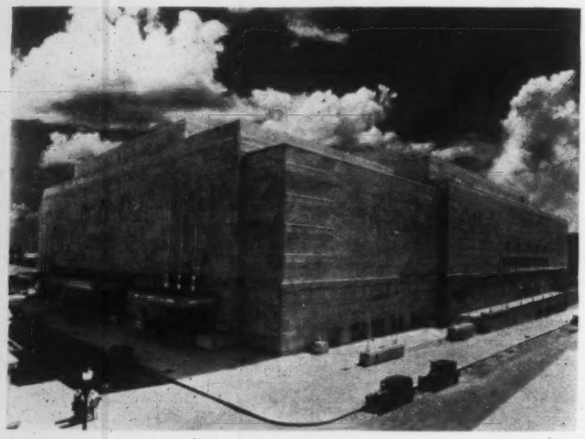
During the winter months, the air temperature is controlled by diaphragm valves connected to the cast iron tempering and reheating coils from duct thermostats in the outside air duct, in the housing behind the reheating coils and in the return duct system. Humidity during the winter is controlled from humidistats in the return duct of each system, operating the water pumps supplying water to the washers. Washers are designed so that only one bank of sprays operates during the heating season, and at a lower pressure.

There is no direct radiation inside the auditorium proper. Unit heaters are installed over the ceiling to take care of the only exposure heat losses, as all side walls of the auditorium are surrounded by corridors or committee rooms that are heated.

All ducts were fabricated in the shop, including the

installation of the insulation, except the large ducts, where due to labor conditions, the insulation was bolted to ducts after erection on the job. Air filters were not installed in the auditorium units; however, space is provided so that filters may be installed in the future if desired.

The system has been in operation for several months, and on recent tests the temperature was held within 1 F



Kansas City's municipal auditorium, which has 1200 tons of refrigeration capacity available for air conditioning

variation throughout the auditorium from floor to ceiling and from empty auditorium to a capacity house. The humidity was kept well within established limits.

Exhibition Space, Theater and Other Rooms

Two 110,000 cfm supply fans and two 90,000 cfm exhaust fans handle the exhibition spaces. All air is supplied through specially designed ceiling splash plates and exhausted through grilles at the floor and ceiling. The air supply and return trunk ducts are installed in tunnels under the floor of the building with branches in furred columns leading to the various ceiling outlets. In these tunnels are installed the heating and plumbing pipes that supply the building.

The ceiling outlets in the exhibition spaces are made of spun aluminum and located so as to clear the flush lighting units and pendant sprinkler heads symmetrically placed in the ceiling construction.

The types of fans, control, heating coils, etc., are similar to those for the auditorium. Smoke exhaust ducts were not installed in this room, but provision was made so that 50 per cent of the exhaust air can be taken from near the ceiling line.

One 95,000 cfm supply fan and one 80,000 cfm exhaust fan handle the theater proper. The air is supplied through diffuser nozzles placed in the ceiling behind the light coves, both on the main ceiling and under each balcony. The air is exhausted through mushrooms on the main floor and on each balcony floor, well distributed over the entire seating area.

Concealed type copper radiation is installed on all outside walls to take care of wall heat losses and to cut down-draft on cold walls.

The general method of control and type of equipment used is similar to that described for the auditorium.

The small theater is air conditioned. The large committee rooms, assembly rooms, and stage dressing rooms are ventilated with supply and exhaust ventilation. The smaller committee rooms are equipped with exhaust ventilation and concealed copper radiation for heating. All toilets, locker, shower, storage, and inside rooms and corridors are equipped with exhaust ventilation connected to a separate exhaust fan system.

Piping Services and Heating System

Heating, cooling, and cold water piping throughout is genuine wrought iron; all service hot water piping is brass, 85 per cent copper, with screwed cast brass fittings. The insulation on all steam and air washer pipe lines is 1¼ in. thick fiberglass insulation. All duct work is open hearth galvanized sheet steel.

Steam is taken from street main at low pressure and distributed throughout the building through a two-pipe vacuum up-feed heating system. The automatic electric driven vacuum pumps in the machinery rooms in the basement take care of the condensation. The combined capacity of the vacuum pumps is 250,000 sq ft of equiv-

Control board in the engineer's room. From left to right are seen the exit light and work light control throughout the building, fan control panel, remote temperature and humidity indicating panel, and the damper and temperature controls

alent direct radiation. Separate systems of supply and return piping are installed for blast coils and direct radiation.

The lighting and power supply for the building is taken from 13,000 volt primary service and reduced in two substations within the building to four wire 199-115 volt, three phase. All power located in the machine rooms, which includes the compressor motors, pump motors, and exhibition hall ventilating fans, is taken off ahead of the regulators. All other power and lighting current is regulated and distributed from a four pole copper bus encased in aluminum housing. The bus encircles the building and connects the two substations. The bus varies in size from 2000 amperes to 4000 amperes depending upon the load carried.

The municipal auditorium was built at a cost of $5,000,000 from a $40,000,000 bond issue voted in 1931 by the people of Kansas City. Cost of the air conditioning and heating system was about $460,000. This work was carried on under the direction of H. F. McElroy, city manager, Mayor Bryce B. Smith, and Matthew S. Murray, director of public works. The architects of the building were Gentry, Voskamp & Neville, and Hoit, Price & Barnes. Structural engineer was Erwin Pfuhl and the author was the mechanical engineer.

Pressure Losses in Rectangular Elbows

[PART 3]

By R. D. Madison* *and* J. R. Parker†

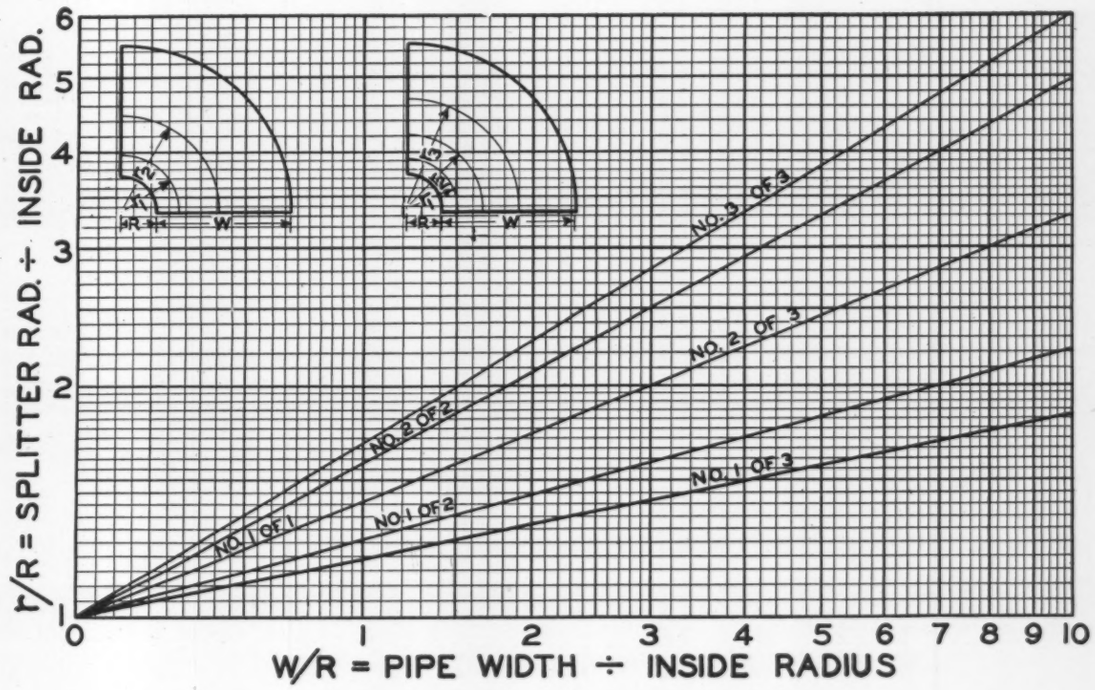


Fig. 11—Chart for determining the location of elbow splitters

SO far, we have considered effect of the radius ratio, aspect ratio, degrees turn of the elbow, elbow size, and velocity.

Effect of Splitters on Pressure Loss

The use of splitters in elbows to reduce the total pressure loss is becoming more and more common, but there is very little engineering information upon the subject at the present time. Having shown (from curve *A*, Fig. 7) that there is very little change in the loss for the usual aspect ratios above unity, the principal benefit to be derived from the use of splitters is through an increase of the radius ratio. It would seem to be desirable to place the splitters in such a position as to obtain equal radius ratios for the smaller elbows formed by the splitters. This will not only simplify the calculation of loss but will also make for greater economy of material.

The necessary calculations for locating splitters to obtain equal radius ratios can be made with the aid of a chart such as is shown in Fig. 11, which is reproduced from "Fan Engineering."[5] The chart is laid out for calculating the position when one, two, or three splitters are used. No. 1 of 3, No. 2 of 3, etc., refer to the respective splitters starting from inside. To use the chart in Fig. 11, divide the pipe width (difference of radii) by the inside radius. Locate this value as an abscissa on the chart, move upward to the desired splitter line (depending on the number used) and then to the left of the chart where the ratios of the splitter radii to the inside radius may be found. These values, each multiplied by the inside radius of the original elbow will give the radii upon which to construct the splitters. Incidentally, it will be observed that the reciprocal of the first or lowest value is the curve ratio of the revised elbow.

The use of curve ratio offers another method of procedure and simplifies the splitter loss calculation. This may be shown by the following:

Let r_a = inside radius of an elbow, r_1 = radius of first (inside) splitter, r_2 = radius of second splitter, r_x = radius of xth (last) splitter, r_b = outside radius of elbow, and x = number of splitters. Now CR = curve ratio of plain elbow = r_a/r_b. Let CR' = curve ratio of each component elbow formed by splitters. Then

$$CR' = r_a/r_1 = r_1/r_2 = r_2/r_3 \ldots\ldots r_x/r_b$$

*Research Engineer, Buffalo Forge Co., Buffalo, N. Y.
†Engineer with Buffalo Pumps, Inc., Buffalo, N. Y.
Contributed by the Aeronautic Division and presented at the Annual Meeting of *The American Society of Mechanical Engineers* held in New York, N. Y., December, 1935. Published in *A. S. M. E. Transactions* for April, 1936.

[5]"Fan Engineering," by W. H. Carrier and R. D. Madison, Buffalo Forge Co., Buffalo, N. Y., 1933.

The authors present data on pressure losses in rectangular elbows as affected by (*a*) the curve ratios of the elbows, (*b*) the aspect ratios of the elbows, (*c*) angle of the bend, (*d*) the elbow size, (*e*) velocity of flow, (*f*) splitters in the elbows, and (*g*) compound elbows. In general, data are given (1) for the elbow situated in a duct system with ducts preceding and following the elbow, and (2) the elbow at the end of a duct and discharging freely into the air

but

$$(CR')^{x+1} = r_a/r_1 \times r_1/r_2 \times r_2/r_3 \ldots \times r_x/r_b = r_a/r_b = CR$$

$$CR' = \sqrt[x+1]{CR}$$

Therefore, it may be seen that the new curve ratio effected by the addition of a single splitter $= \sqrt{CR}$; the curve ratio due to two splitters $= \sqrt[3]{CR}$; etc. Dividing the inside radius of an elbow with splitters by the curve ratio of the elbow gives the actual radius of the first or inside splitter. Dividing the radius of the first splitter by the curve ratio gives the radius of the second splitter, etc. The curve ratio determined in this manner can be used in conjunction with Fig. 9 for determining the expected pressure loss in elbows fitted with splitters. Note that for each of the individual elbows formed by the splitters the curve ratio found by this method is the same as that found by the method employing Fig. 11.

The following example is given to illustrate the method of computing the pressure loss in a 28 in. × 38 in. elbow, with a radius ratio of 1 (curve ratio of 0.33) an aspect ratio of 1.36 and having one splitter. The elbow is considered to be preceded and followed by ducts. Since the inside radius of this elbow is 14 in. locate the point 28/14 = 2 as an abscissa of Fig. 11. Follow this abscissa to the line marked "No. 1 of 1" and read at the left the value of $r/R = 1.72$. Since R/r is the curve ratio for the revised elbow the reciprocal of 1.72, which is 0.58, will be the new curve ratio. The corresponding pressure loss for a curve ratio of 0.58 in a 12 in. elbow (the largest shown in Fig. 9) is 11.5 per cent of the velocity head. This is the same loss that was actually obtained by test on this size elbow. The actual loss on the original elbow (without splitter) was 22.3 per cent of the velocity head compared with a value of 21.5 as read from the curve in Fig. 9.

The pressure loss can be found directly from the curve ratio and Fig. 9. As an illustration of this procedure take a 12⅜ in. x12⅜ in. elbow with a 5 in. throat radius and one splitter. The curve ratio of the original elbow is $5/(17\frac{3}{8}) = 0.288$ and from Fig. 9 the original loss should be 0.25 velocity head. An actual test on such an elbow gave a pressure loss of 0.26 velocity head. Using the previously given equation for determining the curve ratio of an elbow with one splitter, the curve ratio is $\sqrt{0.288} = 0.536$. The loss corresponding to this value as read from Fig. 9 is 0.12 velocity head. An actual test on such an elbow gave a pressure loss of 0.10 velocity head.

These illustrations indicate that a single splitter in an elbow will materially reduce the pressure loss if the value of the curve ratio is sufficiently small. With a curve ratio greater than 0.5 (1½ *RR*) there is little or nothing at all to be gained by the use of splitters. As an example of this, a 6 in. × 6 in. elbow with 0.5 curve ratio was tested, first, with a single splitter and then, with three splitters. From the curve Fig. 9 there would be an expected loss of about 13.5 per cent of the velocity head for the elbow without splitters and about the same value, 13.5 per cent of the velocity head, with one splitter. The actual test with one splitter showed a loss of 12.4 per cent of the velocity head. In the case of three splitters the new curve ratio $= \sqrt[4]{0.50} = 0.84$ which indicates a loss of 22 per cent for a 6 in. elbow. The actual test showed a 17 per cent loss indicating an upward sweep in the loss curve at this point. Where several splitters are used the increase in aspect ratio becomes a more important factor. In the previously given case this would reduce the loss to about 70 or 80 per cent of the loss in a corresponding elbow with an aspect ratio of unity. In view of this fact the test value of 17 per cent is more rational (0.75 × 22 = 16.5). Where one or more splitters are placed in an elbow having an aspect ratio much less than unity, the curves of Figs. 6 or 7 should be applied. Thus, the component elbows formed by the addition of splitters will have lowered aspect ratios and the corresponding loss factors may be appreciably less than that of the original elbow. As the benefit of lowered aspect ratio factors will not be the same for the component elbows the average value may be used. This benefit is in addition to that due to increased curve ratio. Actually there is still another factor. This factor is the size of the elbow, and it will modify test

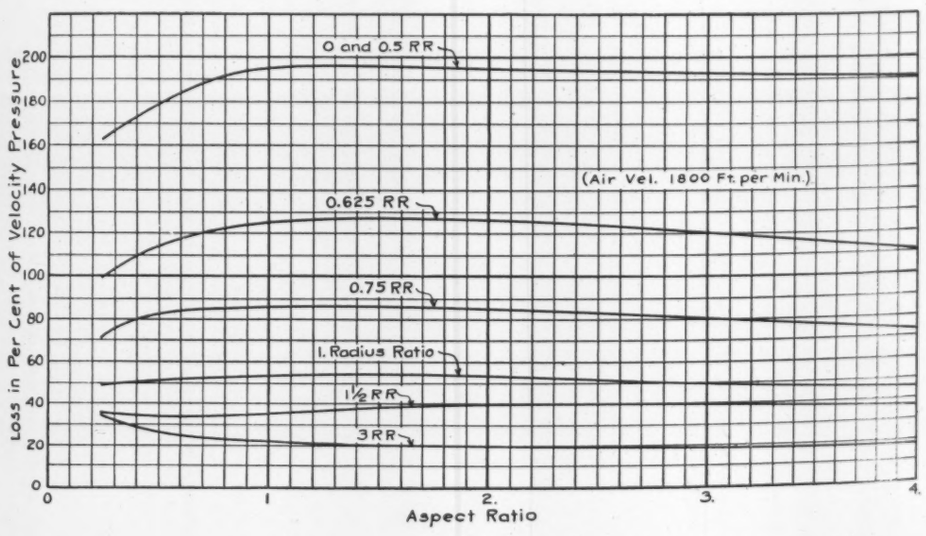


Fig. 12—Pressure losses in 90 deg elbows discharging directly into the air

results but in general it will be simpler to omit this factor, except for very large size variations.

Effect of Elbows at the End of Ducts

Although elbows are used in duct systems generally for changing the direction of flow, they are frequently used as outlet openings with no ducts attached. Since the pressure loss in elbows used for this latter purpose is materially higher than when the elbows are used in a duct system, information should be available on the pressure losses when the elbows discharge directly into the atmosphere. Tests were run on such elbows with a 36 sq in. cross-sectional area and the results plotted in Fig. 12. Attention should be called to the fact that these elbows had 1 in. extensions on each end for connecting them to ducts and so there is a slight modification from

Case No	First Elbow		Second Elbow		Elbows Only			Elbows followed by Duct		
	RR	AR	RR	AR	Act.	Est. Sum	% of Est.	Act.	Est Sum.	% of Est.
(1.)	3.	4	1.5	4.	37.2	48.5	77	27.6	21.5	128.
(2.)	1.5	4	3	4.	24.2	30	81.	26.4	21.5	123
(3.)	1.5	4	0.5	4	245.	202.	121.	115	85.	135.
(4.)	0.5	4.	1.5	4.	162	112.	69.	103	85	121.
(5.)	1.5	4	1.5	0.25	45 5	48.	95	34.6	38.	91
(6.)	1.5	0.25	1.5	4.	55.	65.	85.	38.5	38.	101.

Fig. 13—Test results on 3 in. x 12 in. compound elbows

a true 90 deg turn. This modification varies with the radius ratio and probably with the aspect ratio. When a 6 in. × 6 in. elbow with 0.5 *RR* had the 1 in. extension on the discharge side removed, the pressure loss fell from 195 per cent to 172 per cent. This was due to reducing the effective angle of turn in the air flow although a complete 90 deg metal elbow remained. On the same size elbow but with a radius ratio of 1½ no appreciable difference in loss resulted when the elbow was reduced to a standard 90 deg turn.

Comparing the results of Figs. 12 and 5 it will be

Case No	Plain Elbows			1 Diameter Between Elbows			Splitter in Each Elbow		
	Act.	Est. Sum	% of Est.	Act.	Est. Sum	% of Est.	Act.	Est. Sum	% of Est.
(1) 5"R 12⅜"	104.2	100.	104.	54.9	100.	55.	26.	30	87
(2)	93.7	100.	94	106.	100.	106.	22.	30.	73
(3)	65.5	100.	66.	75.1	100.	75.	27.4	30.	94
(4)	43.	52	83.	31.4	52	60.	15	20.	75.
(5)	62.2	52.	120.	68.3	52	131.	18.8	20.	94
(6) Length = 4D	41.8	52.	81.	45.7	52.	88.	20.5	20.	102.

Fig. 14—Test results on 12⅜ in. x 12⅜ in. compound elbows

observed that for common elbows having radius ratios between 1 and 2 and aspect ratios between ½ and 2, the elbow discharging directly into the air has a loss from 2½ to 3 times the same elbow when followed by a duct. The effect of using splitters is to lessen the regain value of the following duct and to lessen the difference in loss when the elbow is tested in the two different manners.

Effect of Compound Elbows on Pressure Loss

The use of two elbows adjacent to one another often becomes necessary in duct work, and while the losses may be figured separately for each of the component parts of the compound elbow, the combined loss as determined from tests may be considerably different from those obtained by calculation. Several of the simpler combinations were tested by the authors with the results as shown in Figs. 13 and 14.

In these figures the column labeled "estimated sum" is the sum of the test losses in the separate elbows, assuming that in each case the first elbow in the line of flow is always followed by a duct. In case the second elbow discharges directly into the air, the assumed value for the loss in the second elbow is from tests in which no discharge duct was used. In case the second elbow

Summary

1. Curve ratio (or likewise radius ratio,) is the predominating influence on pressure loss in elbows. The loss is high and critical for low curve ratios and low and stable for high curve ratios. Little or no advantage is gained by using curve ratios greater than 0.6 (radius ratio of 2).

2. The effect of aspect ratios greater than unity is small and may be neglected for ordinary work. For low aspect ratios the loss is more pronounced and aspect ratios less than ½ warrant the use of a splitter in the elbow.

3. The amount of the loss is not exactly proportional to the angle of the bend, but becomes somewhat less in proportion as the angle increases.

4. The size of the elbow has relatively little effect upon pressure loss in elbows in common use. In elbows with large curve ratios the pressure losses approach the values for straight ducts.

5. Velocity has very little effect on elbow losses when given in per cent of velocity pressure, the losses being comparable to those due to friction in a straight duct. Where the curve ratio of the elbow is very small, approaching sharp corner conditions, the loss will vary nearly as the square of the velocity.

6. If the air flow is not uniform in a duct just preceding an elbow, the loss will be somewhat higher than normal if the high velocity is along the inside of the elbow and will be somewhat lower than normal if the high velocity is along the outside of the elbow.

7. The flow conditions along the inside of the elbow are more critical than elsewhere, and if the elbow and duct do not align properly, a disturbance at the inner side is more detrimental than elsewhere.

8. Where elbows of small curve ratios must be used, a splitter is a very effective means of lessening the pressure loss. For elbows with curve ratios of 0.2 to 0.3 the use of a single splitter will reduce the loss to about one-half the normal value.

9. Elbows discharging directly into the atmosphere may have high losses which can be effectively reduced by splitters or by attaching a short section of straight duct to the discharge end of the elbow.

10. Compound elbows may have losses considerably different from those estimated from tests of the individual elbows used to make up the compound elbow.

is followed by a duct the corresponding test value is used. This method is the most logical one for combining the losses in compound elbows.

The column labeled "per cent of estimate" is the ratio of the loss obtained by testing the compound elbow to the estimated loss as just outlined and serves as a means of showing the extent of the error in this method of determining the combined losses in compound elbows.

Any constraining shape of like dimensions following an elbow tends to lower the loss below that of an elbow discharging freely into the air. Thus a second elbow helps to lower the loss of the first as compared with a free discharge of the first. The influence of the first elbow may help or hinder that of the second elbow depending on the conditions of flow produced at the discharge of the first. Note that in Fig. 13, the elbow loss for Case 3 does not differ greatly from the loss for Case 4 when the elbows are inserted in a duct, being 115 and 103 per cent, respectively; but that the losses are vastly different when the second elbow discharges directly into the air, the losses in this latter instance for Cases 3 and 4 being 245 and 162 per cent, respectively. It is interesting to note that in the case of elbows forming a side turn and having an aspect ratio near unity, as in Case 3 of Fig. 14, the combined loss of 65.5 per cent is lower than that of each tested alone (73.5 per cent) when not followed by ducts. Such a condition was noted during tests on a large compound elbow (28 in. × 38 in.) with aspect ratios of 0.74 and 1.36, in which the second elbow made a side turn and discharged directly into the air. In this case, despite the arrangement, the combined loss was between 8 and 10 per cent lower than the loss due to either elbow tested separately and not followed by ducts.

The values in Columns 4, 5, and 6 of Fig. 14 are given to show the influence of one diameter of duct placed between the elbows. Note that in Cases 1 and 4 the duct caused a decrease in the pressure loss while in the remaining cases it increased the pressure loss, thus hindering the flow.

The benefit of splitters in elbows and especially those discharging freely into the air is evidenced from a study of Columns 7, 8, and 9 of Fig. 14, wherein it is seen that the splitters materially reduce the pressure loss.

Definition of Terms

For convenience, definitions of terms used are repeated here; for complete definitions, see page 365, July issue.

For the purpose of this paper, all elbows of the same size are referred to as having the same cross-sectional area. The velocity V through the elbow or duct is the average velocity, *i.e.*, the quantity of flow divided by cross-sectional area.

The radius ratio is designated as RR and defined as the radius of the center line of the elbow divided by the depth in the plane of the bend, *i.e.*, divided by the difference between the outside and inside radii. A new term is used in addition to radius ratio, the *curve ratio*, designated as CR and defined as the inside radius of curvature divided by the outside radius of curvature.

The aspect ratio AR is the width of elbow along the axis of bend divided by the depth in the plane of the bend. High aspect ratios characterize "easy" bends and low aspect ratios characterize "hard" bends.

The term "duct friction" is referred to as the normal friction of straight ducts or that portion of an elbow loss which corresponds to duct friction.

Acknowledgments

The authors wish to express their appreciation to the Buffalo Forge Co. which sponsored most of these tests and to the engineering department of that company for valuable assistance rendered during the tests and in plotting results.

[*Concluded*]

Welding Lead Sheets and Pipe

By F. E. Rogers*

Lead burning, or the welding of lead with a gas torch, is employed in applying linings to acid and other tanks used in plant processes, and in the joining of lead piping for process services. . . . The author describes in some detail the elements of success in this work, and includes many practical suggestions

LEAD burning, so-called, is the welding of lead with a gas torch. The edges of the lead are fused and flowed together, using no solder but pure lead only to fill and reinforce the joint when filler is required. The term "lead burning," therefore, is a misnomer as the metal is not "burned," but is fusion welded as other metals are welded with the torch. The methods, however, are quite different from those used on other metal welding.

The process is employed in applying the lead linings of acid and other tanks used in chemical plants, fertilizer factories, rubber reclaiming works, electroplating shops, artificial silk or rayon factories, nitroglycerine huts, and industrial plants employing corrosive liquids. Lead welded joints are displacing the plumber's wiped joints for lead pipe connections in chemical and other plants.

Tank linings for acids should be made of "chemical" lead, that is, sheet lead free from impurities. Ordinary sheet lead used for gutters and other purposes is likely to be of inferior quality. Antimonial lead, while stronger than chemical lead, has not as good corrosion resistance.

Chemical lead is denser and heavier than antimonial lead, and has higher acid corrosion resistance, but for situations requiring strength and freedom from "crawling," 6 to 10 per cent antimonial lead is used. The weight of 6 per cent antimonial lead is 5 per cent less than chemical lead for equal volumes, while 10 per cent antimonial lead is 8 per cent lighter.

Chemical Lead: Melting point	621 F
Specific gravity	11.38
Weight per cu ft	710 lb
Weight per cu in	0.4105 lb
Tensile strength per sq in	1900 lb
Elastic limit per sq in	700 lb
Antimonial Lead, 6 per cent: Melting point	487 F
Specific gravity	10.81
Weight per cu ft	675 lb
Weight per cu in	0.3906 lb
Tensile strength per sq in	3625 lb
Elastic limit per sq in	3000 lb

"Crawl proof" lead is chemical lead strengthened by antimonial lead bars running the length of the sheet and protected by the chemical lead. Tellurium lead is an alloy lead containing about 0.1 per cent tellurium to increase acid-corrosion resistance and tensile strength.

Cleaning, Preparation and Forms of Joints

Considerable skill is required of a lead welder to unite lead sheets rapidly and uniformly. The beginner is likely to overheat and "burn" holes in the joint, to say nothing of his difficulties in making welds rapidly that measure up to the standards of lead joint work. Success depends on good tools, thorough preparation, clean surfaces, suitable gases and apparatus, pure lead and proper working conditions, as well as the skill of the operator.

Two forms of joints are used with sheet lead—the butt and simple lap seam. Both are employed in tank lining and also in lead pipe jointing. In preparing a butt joint between the heavier weights of sheet lead when filler is used, the edges should be trimmed straight and beveled to an angle of 75 to 80 deg, making a vee of about 30 deg included angle when the two sheets are butted. The sides of the sheets are scraped clean of oxide, about ½ in. from the edge, using a sharp shave-hook. The edges are tacked, placing the tacks about 1 ft apart, and the groove between is filled with molten lead fused from a welding rod or burning bar. The seam is usually reinforced with lead which is so applied that it flows and forms peculiar patterns, the shapes varying with the spacing and amount deposited from the filler bar at the successive points of application.

Butt joints are not much used in tank linings, however, except with very heavy lead, so thick in fact that it is rarely employed. When making butt welds, all thicknesses up to, say, 12 lb to the sq ft (3/16 in. thick) are butted with square edges, and generally are welded with filler rod. The edges of sheet lead heavier than 12 lb are beveled as previously stated to form a vee groove.

How the Joints Are Made and Welded

When welding a butt joint with filler, the flame envelope or streamer is played on the edges of the sheets until the metal is softened but is still too stiff to flow freely. Lead is added from the filler rod by fusing from the end, also with the flame envelope, giving the torch and filler rod a peculiar periodic up-and-down movement which deposits the required amount of molten material on *each spot*. The deposited molten lead flows and hardens in a pattern depending on the thickness of the lead, weight of the filler rod and amount of lead

*Applied Engineering Dept., Air Reduction Sales Co., New York, N. Y.

Top to bottom—Scraping a joint to prepare it for welding; all oxide must be removed before welding lead. . . . Making reinforced ripple butt weld, level seam, in 16 lb sheet lead. . . . Butt welding 4 in. lead pipe weighing 16 lb per lineal foot. . . . Making a vertical lap weld, using no filler rod, 6 lb sheet

deposited at each movement. The next application of lead from the filler rod, if accurately spaced, flows into and slightly overlaps that previously laid on. The lead welder progresses in this manner, depositing globs of molten lead evenly spaced along the length of the joint.

Lap seams are mostly used in tank linings, especially in the vertical joints when a smooth surface is not required. In making a lap seam, the top sheet should lap the under sheet about 1 to 1½ in. All dirt and oxide must be removed carefully from the joint with the hook scraper or shave-hook.

When making a lap weld, especially in a vertical joint, the torch flame is directed close to the edge. No filler is used. The manipulation of the torch is quite different from that employed when making flat seams of either the butt or lap type. Not much lead can be fused at a time because of the probability of dropping. The overlapping edge is "carved" with the flame, and the molten lead slips down and chills on that which was fused at the previous flame application. The welder sometimes uses a tool—a shave-hook for example—to hold the sheets closely together, and sometimes to help chill the fused metal should it tend to slip down too far or to drop.

The fusion process on vertical seams, the same as on flat seams when filler is employed, is a succession of in-and-out torch movements and progressive movement along the seam with each application of the flame, but the flame is also moved sideways about ¼ in., thus "carving" out a section of the edge which fuses and flows down and rests against the previous deposit.

Torches and Gases

The heat required for lead welding is low in comparison with that used in welding cast iron and steel, being only about 620 F, as compared with 2000 to 2700 F. Hence, if a high temperature gas is employed, it means a smaller tip than when using hydrogen. Small light torches are used that can be easily handled. Old-time lead burners were trained to use hydrogen (generated with acid and zinc) and compressed air, but the introduction of oxy-gas welding equipment and compressed oxygen, hydrogen and acetylene in convenient cylinders has changed lead welding practice to considerable degree. However, very simple and cheap torches are employed as a rule with hydrogen, consisting of little more than a light tube bent to a gooseneck and fitted with separable tips. The mixed gases are supplied by means of a light rubber tube connected to a benchblock which carries the adjusting needle

valves. This arrangement enables the operator to adjust the valves to the flame he desires, and then he can go ahead with his work without danger that the flame may be changed by accidentally touching the valves as might happen if the valves were on the torch. With the primitive torch just described, in the case of a flash-back all that happens is the rubber tube is blown off the bench-block as it is not wired to the gland.

The lead welder necessarily becomes expert in working lead within narrow temperature limits. He must heat the metal at the joint to the near fusing point but not so much that it becomes too fluid and drops away. *He must scrupulously clean the joints and avoid touching them with the hands or anything unclean, as the slightest trace of oil or grease will give trouble.*

The first operation to be learned is to choose the tip size and regulate the flame. The volume of heat necessary will depend upon the thickness of lead being burned and to some extent on the surrounding conditions and the backing.

Weight of Lead and Sizes of Burning Bars

Lead sheets, 2, 4, 6, 8, 10, 12, 16, 20, 24, 30, 40 and even 60 lb to the sq ft are commonly used in chemical plants. Thus, twelve thicknesses of lead, ranging from 2 to 60 lb to the sq ft, the latter being thirty times as thick as the former, are presented for welding. Hence, it is quite apparent that the lead welder must be able to regulate and adjust his flame to a wide variation in the thickness and weight of lead.

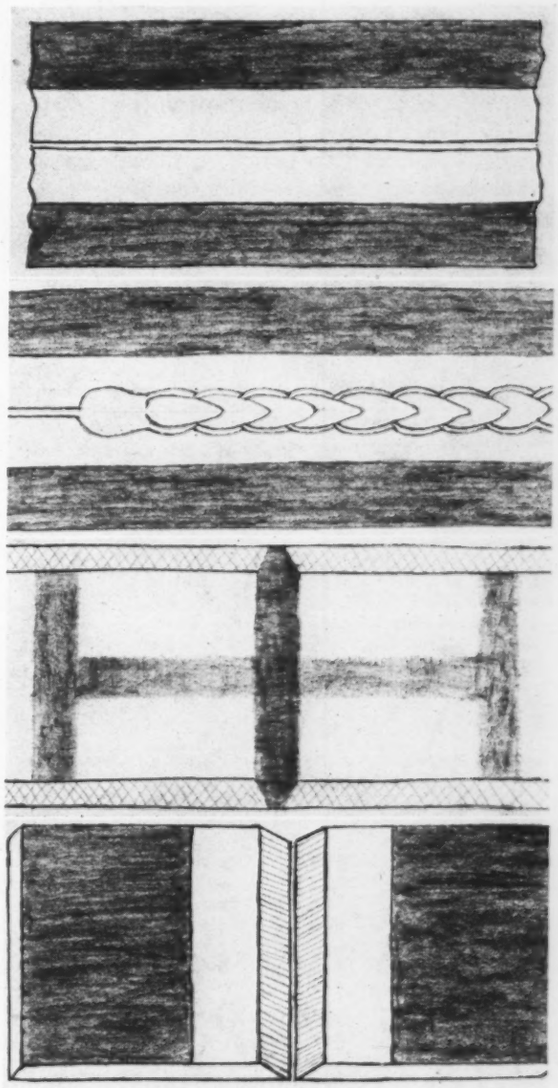
The cross-section of the lead filler or burning bar depends on the thickness or weight of lead to be welded; ⅛ in. wire size is recommended for 2 and 4 lb lead; 5/16 in. size for 6 and 8 lb lead; and ⅜ in. and ½ in., depending on the type of seams, for 10, 12, 16 and 20 lb lead. The importance of using lead welding rods of the correct size for each weight of lead can hardly be over-emphasized. If the bar is too light, the time required to fuse the lead needed for each deposit permits oxidation to take place due to the fact that the metal is light and is likely to be overheated. If a heavy bar is used with a small flame, the metal does not melt sufficiently to carry on the seam and the seam chills during the lost time period while the flame is melting the lead. Fusing the filler is done over the sheet of course, and the time interval between fusing the burning bar and depositing it on the sheet must be carefully gauged. If the bar is too heavy or too light, the proper sequence of heating the sheet, fusing the lead, depositing it on the seam and so on, cannot be maintained as to time interval. This means lost time, irregular work, low speed and oxidation, edges of seams not welded, pits, cold-shuts and other defects.

A well-regulated flame of size in proportion to the weight of lead and the proper size of burning bar are important also on pipe work, the same as on sheet lead.

Great care must be taken in properly scraping all dirt and oxide from the surface with the shave-hook before burning. Avoid rubbing the hands over the work after scraping. Always use a dust brush or counter brush to remove the scrapings or raspings produced in preparing a joint. After the lead is scraped clean at the joint, brush the shavings away from the seams and from beneath. Dress the lead down tight to the tank with a wooden mallet, tack the edges together with the torch at, say, every foot, but always keep the lead dressed down flat to the tank surface. This saves time in welding and prevents molten lead getting beneath the sheet.

Lining Tanks

Should the welder be relining an old box or tank where the wood has been saturated with the contained liquors, a strip of sheet asbestos about 3 in. wide should be used under the seams. The bottom of the tank should be wiped dry and made as free from moisture as possible. The asbestos insures againt the acid or liquor soaked into the wood from bubbling up through the seams when the burning is being done. Watch carefully back of the flame to see that bubbles do not break through. Gas will often do this between the tank and lining, and, of course, if this happens a defective spot is made which must be made tight.



***Top to bottom*—Lead sheets, edges scraped for butt weld. . . . Butt reinforced weld in 4 lb sheet lead, ripple space 7/16 in. . . . Split lead joint in 2 in. inside diameter extra strong lead pipe; bottom welded from inside of pipe; lighter lines show split welds. . . . Beveled 30 lb lead sheets ready for welding**

Again, where iron tanks are lead-lined, care must be taken that gases are not formed between the tank and lining. But as this work is in a class by itself the matter will not be further treated here except to say that gas formed back of linings is one of the major troubles against which the lead welder must guard.

Upright or vertical seams must be scraped, as follows: Lap the lead 1 in. to 1½ in., scrape the lower or back sheet before the lead is dressed down. Do not fail to scrape the under side as well as the outside. This is why some lead welders have so much trouble in upright or overhead welding. Everything depends in this class of work on properly prepared joints and proper regulation of flame. Remember also that a drop of metal lost on overhead work must be replaced with one from the welding rod or burning bar, otherwise the seam will look bad, and it will be hard to start back at the edge of the sheet. Overhead welding requires practice and care to prevent the flame from distributing heat except where the burning is actually being done.

Lead Pipe Welding

Lead welding is used for all kinds of piping joints in chemical plants. Flanges are used only where lines are to be broken from time to time, due to various causes, such as clogging with sediment or being eaten up by acid or where quick repairs must be made.

Wash-out opening are placed in certain lead pipe lines so that they may be cleaned quickly. When such a line is a vital part of the operation, all joints should be carefully welded so that the joints will withstand more corrosion than the pipe itself, or, in other words, the welding should not pit the wall of the pipe or take any lead from the wall thickness. In making such pipe joints, always add from the welding rod or burning bar to build up the seam or joint.

The following lead pipe joints are recognized and used in lead pipe work: Roll, cup, butt, split, flange, burned-in, flange using cast iron or brass flanges, and lap.

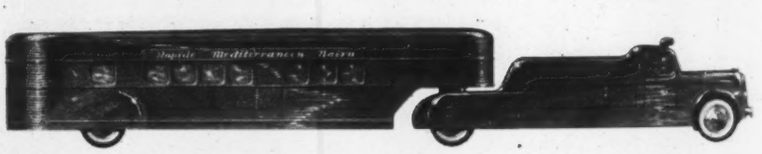
Lead Pipe Sizes Used in Chemical Plants

Inside Diameter In.	Outside Diameter In.	Weight per Foot Lb	Weight per Foot Oz	Thickness of Wall In.
¼	11/32	0	4	1/16
¼	7/16	0	8	3/32
3/8	23/32	1	9	1/8
½	11/16	2	1	3/32
¾	1 5/32	3	0	1/8
1	1 7/16	4	0	3/32
1¼	1 11/16	4	12	7/32
1½	2	6	8	¼
2	2½	9	0	¼
3	3½	12	8	¼
4	4½	16	12	¼
6	6 1/16	24	0	5/16

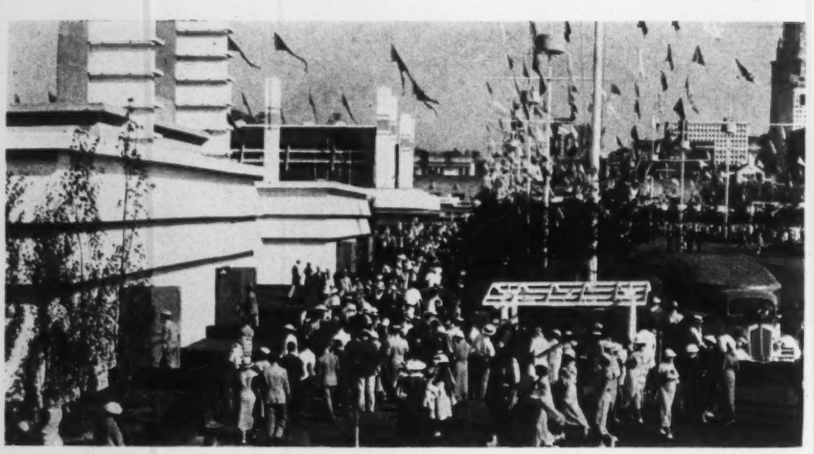
Welding Lead Butt Joints When the Under Side is Inaccessible—Often the maze of lead pipes in a plant includes some so laid that the underside is inaccessible for welding. When it becomes necessary to replace a section and weld it in with butt joints heavy expense would be incurred for removing and replacing the underneath obstruction, or cutting several side connections and rewelding.

In such cases the pipe ends are split back at the top two or three inches. Cross cuts are made at the ends of the splits about halfway through, or down to the middle of the pipe, as shown in one of the sketches. The split parts of the pipe are bent outward, thus exposing the inside and permitting the underside of the butt weld to be made by working on the inside of the pipe. When the weld is made halfway around the cut parts are bent back into place and the cross cuts, splits and butt welds are made, thus closing the pipe and completing the job.

If the ends of the pipe are beveled, the lower halves are beveled inwardly, and the upper halves as usual.



One of two air conditioned, light weight stainless steel trailers being built by Edward G. Budd Mfg. Co. for the Nairn Transport Co. for the 530 mile, 15 hour run over the Syrian desert between Baghdad and Damascus. They will be drawn by 150 hp diesel tractor units. One is a day coach and the other is for sleeper use



At Cleveland's Great Lakes Exposition. In the Hall of Progress, the building at the left, the Cleveland Electrical League's exhibit portrays by means of miniature rooms the importance of temperature, humidity, circulation, and air cleaning. For instance, air from the streets is blown into one miniature room, is seen to collect on little tables, chairs and other furniture. A second room, the air to which is filtered, provides the contrast

Air Conditioning Makes Severe Demands on Water Supply and Disposal Systems

INCREASED demands on water supply and disposal facilities because of condensing water requirements of the fast growing number of air conditioning installations have caused serious consideration to be given to the solution of the problem in several cities, and are expected to lead to the wider use of water conserving equipment, such as cooling towers and evaporative condensers, and to other methods of cutting the requirements on city mains and disposal systems. The problem divides into two phases, first, where the limitations in the water supply must be considered, and second, where, the disposal of the water after its use in the air conditioning plant is involved. Of course, many water officials look forward to increased consumption for air conditioning and increased revenues, the viewpoint depending on available supply and plant capacity.

In Chicago, for instance, certain sewers in the downtown section—built many years ago and already overloaded—are inadequate to carry off the waste water; one large plant recently put into operation uses 1500 gpm of condensing water. The only solution, according to city engineers, is larger sewers. In Lincoln, Neb., there were a number of smaller cooling installations hooked up with the sanitary sewer system, and had the situation been permitted to continue, it would have been necessary to increase the sanitary sewer system, according to Superintendent of Streets Cobe S. Venner, who introduced an ordinance which was recently passed to take care of the situation. The ordinance provides that the effluent from any air conditioning or refrigeration equipment shall not be discharged into any street or alley, but into the public storm sewer; where a storm sewer is not available, the city engineer may, in his discretion in cases where the discharge from any building is not more than 10 gpm, permit such effluent to be discharged into a sanitary sewer, and provided further that in residential districts the city engineer may permit the effluent to be wasted on to private lawns. The ordinance applies to plants heretofore as well as hereafter installed.

In Cincinnati, water main capacities are limited with little opportunity of increasing sizes or duplicating present mains owing to narrow streets occupied by other services and utilities besides the water works, according to Water Works Superintendent A. S. Hibbs. In one case, says Mr. Hibbs, a large air conditioning system using water direct from the main to the sewer through a 6 in. meter dropped the pressure in the downtown district almost 5 lb. The water works department is therefore working as closely as possible with contractors and is asking that the use of city water for condenser cooling be limited to a 3 in. meter, or about 300 gpm. In cases where more than this amount of water is required, the installation of cooling towers or evaporative condensers is suggested.

A number of speakers and writers have given consideration to the subject in recent months. A paper by D. C. Morrow on water supply as affected by the demand for summer air conditioning was presented at the recent joint meeting of the *A.S.H.V.E.* and the *A.S.R.E.*; this paper was published in *Refrigerating Engineering,* June, 1936, and was summarized in the proceedings of the *A.S.H.V.E.* semi-annual meeting on pp. 462-463, *A.S.H.V.E. Journal Section,* August, 1936, issue of HEATING, PIPING AND AIR CONDITIONING.

L. L. Lewis has addressed several local water works associations on the subject, and later presented a paper, with L. H. Polderman, before the *American Water Works Association;* his earlier paper is abstracted here.

Writing in the July, 1935, HEATING, PIPING and AIR CONDITIONING from South America, Rudolf Kuhlmann de-

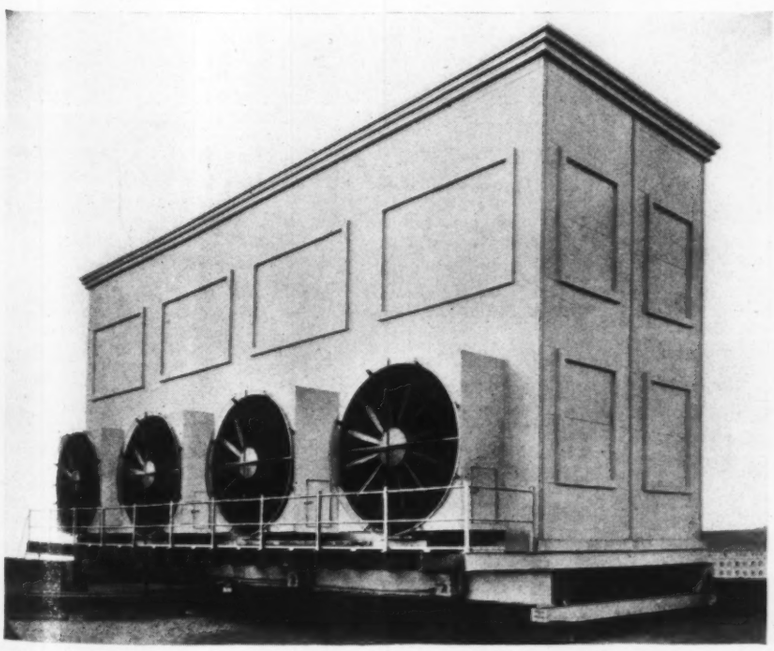


Photo courtesy The Marley Co.

Cooling tower for 1100 ton department store air conditioning system designed to deliver 3400 gpm of 85 F water under maximum wet bulb conditions. Main casing is 20 ft wide, 60 ft long, and 30 ft high. Four 120 in. diameter, 12 blade fans operating at 300 rpm require a total of approximately 50 hp at full load. Note ornamental trim enhancing appearance of tower

scribed water conservation methods in Rio de Janeiro and other cities, including the use of cooling towers, evaporative condensers, spray ponds, wells, and an installation where water taken from the city mains is passed through surface coolers and returned to the mains. Walter L. Fleisher has proposed the use of salt or raw water for condenser purposes, in cities bordering on an inexhaustible supply, and a discussion by him appears below. The Tribune Tower, Chicago, saved $8,000 in condensing costs in 1935 over 1934 by installing a closed circuit from the nearby Chicago river to the condensers and direct to the sewer, according to Holmes Onderdonk, manager of the building, in an interview published in HEATING, PIPING AND AIR CONDITIONING, October, 1935.

A "round table discussion" on the effect of air conditioning on water consumption appeared in *Water Works Engineering*, October 30, 1935; one comparison is particularly interesting. An air conditioning system for a general office has two 30-ton compressors, one of which usually carries the building for 24 hr a day operation; water is wasted to the sewer, the consumption being 11,958 cu ft per day. A restaurant installation in the same city has four 15-ton units, a forced draft cooling tower, and operates 16 hr per day; necessary make-up water is estimated to be 190 cu ft per day.

A. R. McGonegal, in a paper presented before the *Maryland-Delaware Water and Sewerage Association* reported in *The American City* magazine, February, 1936, said that the threat of greatly increased consumption which hangs over the heads of water officials lies in the demand for air conditioning, as the growth of the air conditioning industry has been phenomenal. He stated that a small residential air conditioning plant will consume more than 4500 gal per day, and that a corner grocery, a beauty parlor, or a small moving picture house would use some 30,000 gal. He advised his hearers to watch water consumption, check sources of supply, and give serious thought to a proper balance for the future.

Air Conditioning in Relation to Water Consumption, by L. L. Lewis*

A simple way to get rid of the heat from an air conditioning plant is to buy water and pass it through the condenser to the sewer. If this were the only way to do it, you might well be concerned by the demand. But, in certain cities, the cost of water was high and the manufacturers of air conditioning and refrigerating equipment sought means of reducing the water costs. And so, economic forces stimulated the development of equipment which would reduce sales resistance by reducing the need for water where rates were high, or where the threat of water shortage might restrict its use. This has borne fruit, so that there is available water conserving equipment which may, in some localities, reduce water sales you would like to make but which may, in other localities, save you from excessive demands.

The first stage of this development—ante-dating air conditioning—was the cooling tower. The second stage was the development of the evaporative condenser in which the functions of the condenser and the cooling tower are combined.

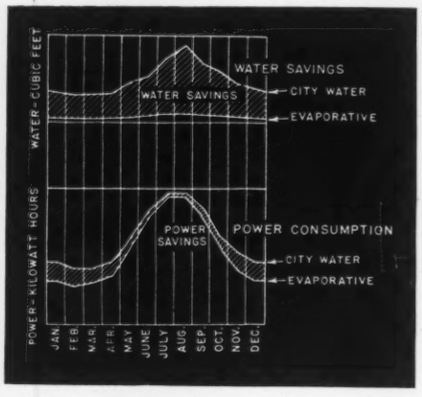
*Chief Engineer, Carrier Engineering Corp., Newark, N. J. Abstracted from a paper published in the *American Water Works Association Journal*, March, 1936.

Demand for Water

What is the magnitude of this demand for water going to be and what will be its characteristics?

Let us examine the demands for water of the several types of prevalent installations of air conditioning, which are given in Table 1.

Btu per person will vary somewhat for each installation, but limits of variation are well known. Hours of



Water conservation made possible by use of evaporative condensers

operation per season can readily be set for maintenance of the desired conditions. Load factors, or the relation of average load to maximum load, are based on experience. Gallons of both maximum and average demand must be based on an average water temperature and an average balance between water and power.

Hence, Table 1 is necessarily composed of figures which are admittedly controversial as to the interpretation of experience, for multifarious economic forces press in some localities for excessive use of water and in others for conservation thereof.

For a given power rate, cold water may throw the balance in favor of heat disposal entirely by water—warm water may do the opposite. Low power rates may favor the conservation of water—high power rates, the opposite. The complexity of these economic forces be-

Table 1—Demands of Several Types of Air Conditioning Installations for Water

Values are per person; season of 120 days; water cooled condensers

	Btu per Hr	Maximum Demand, Gal per Hr	Hours Operation per Season	Gal per Season at Maximum Demand Rate	Load Factor, per Cent	Probable Use, Gal per Season
Residence	4,000	40	2,900	116,000	30	34,800
Train	1,400	14	1,200	16,800	50	8,400
Office	4,700	47	1,200	56,400	40	22,500
Lunch room	1,600	16	900	14,400	50	7,200
Restaurant	2,000	20	1,200	24,000	60	14,500
Drug store	2,000	20	1,800	36,000	60	21,500
Theater	1,000	10	1,500	15,000	30	4,500
Department store	1,600	16	1,200	19,200	60	11,500
Average	2,300			37,000		15,600

comes apparent when it is realized that power for air conditioning may cost from less than 1 to more than 3 cents per kw-hr; that water may be purchased at rates varying from $0.45 up to $2.85 per 1000 cu ft—perhaps higher; that the temperature of water coming from mains may range in summer from 56 F to 85 F, and that the pocketbook limitations as to available capital may enforce the purchase of equipment which is above average in demand for water or power, or both.

But, let's continue our examination. Three important facts are obvious.

First, that the demand for water is seasonal. It is high in summer and insignificant in winter. A 120 day cooling season is typical of New York. In the South, it may exceed 150 days.

Second, that economic forces and restrictive regulations, such as are now applied in New York, did, in 1935, lead to extensive purchase of evaporative heat disposal systems. As a result, water consumption was cut 60 per cent.

Third, that within the cooling season, the peak demand is far above average consumption.

In my opinion, an early achievement of the Utopian condition of an air conditioned spot for each and every person in a city is beyond the most pleasant dreams of the air conditioning industry. Countrywide, it would mean that sales will have totaled $4,000,000,000 to $5,000,000,000. If annual sales of air conditioning doubled regularly every four years, and without regard to obsolescence, the total air conditioning installed will have reached $500,000,000 in 1945, and $1,000,000,000 in 1950.

If air conditioning is sold at such a rate, at some time in a period between 1945 and 1950 the per capita water demand will become:

(1) Maximum rate—35 gallons per day
(2) Average rate— 5 gallons per day

provided the present practice of using evaporative condensers and cooling towers is maintained. But if evaporative condensers and cooling towers be used exclusively from now on and be substituted for existing condensers now wasting water, then these two rates would be cut to:

(1-a) Maximum rate—23 gallons per day
(2-a) Average rate— 3 gallons per day

No process of averaging out, however, can prevent the other fellow's sore leg from hurting him. You divide, therefore, into two groups:

1. Those to whom air conditioning offers an opportunity to sell more water.
2. Those to whom any increased demand will present a serious problem, or who may now be unable to meet existing demands if rainfall is below average.

Conclusions

(a) With respect to Group 1, the maximum demand of 23 to 35 gallons per capita per day may overtax your pumping equipment or, if not that, the capacity of your mains in certain focal points.

(b) With respect to Group 2, your inability to assure a continuity of supply, either at present rates of consumption, or at present rates plus 3 to 5 gallons per capita per year average, or to pump and distribute as in (a), should be faced squarely as the facts stand, and proper restrictive measures instituted.

Use of Raw Water for Condensing Purposes, by Walter L. Fleisher*

In the regulations for consumers of water issued by the department of water supply, gas and electricity of the City of New York, it is stated: "Use of water other than for sanitary purposes, domestic consumption or commercial purposes, is granted under such conditions or reservations as the department may consider reasonable and provided no unnecessary waste exists. The department, however, reserves the right to prohibit such extraordinary use of water if water supply conditions so warrant."

This particular clause, in a way, is a threat, that in case of drought or inadequate water supply, the first thing that would be cut off would be the city water supply used for condenser purposes. The growth of the city and the new use of water is presenting a problem to New York which is likely to become dominant at any time. It is reasonable to expect, with the increased use of water in air conditioning, that within a year or two large users of water for condenser purposes will be prohibited from using city water. Anyone, therefore, entering into the use of air conditioning for summer cooling, in which city water is used for precooling or condenser purposes, must face this situation and design his system for the required amount of cooling tower water necessary for its operation. As New York City water runs from about 67 to 70 F and as cooling tower water may run as high as 82 to 85 F, it can readily be seen that provision must be made by furnishing facilities for handling two or three times as much cooling tower water as city water.

In a city such as New York or Boston, or any of the cities bordering on salt or raw water in inexhaustible supply, thought should be given to the use of this water for condenser purposes. In the first place, it is inexpensive, even though new mains have to be laid to carry it to where it might be used. The water itself requires only screening to remove large solids, and the pipes require no insulation, very little need of expansion and practically no care in their upkeep. As these sources of supply are usually at least as cool as cooling tower water, and possibly cooler most of the season, the only care that would have to be taken in the installation of equipment would be the selection of material which would stand the corrosive action of brine. As most of the condenser work that has been done has evolved around the use of salt water on ships, this is not in any way a new problem, being one which has already been solved and practiced by manufacturers of condensers who cater to the shipping trade.

In those communities where central steam heating systems or central water systems are being laid, increased or augmented at the present time, it is, indeed, the point of wisdom for those utilities now looking for the air conditioning business of the communities in which they operate, to lay lines which can be used for condenser purposes at the same time that they are laying their other lines. We Americans have a habit of closing our

*Consulting and Advisory Engineer, New York, N. Y. Member of Board of Consulting and Contributing Editors.

eyes, to a certain extent, to the future, but the increased use of a cooling medium or a transfer medium, such as water, for air conditioning purposes must be very thoroughly reckoned with at the present time if we are to preserve our expensively obtained pure domestic water, the source of which is receding further and further from the centers of use as we require more and more for domestic usage.

The question may arise as to the danger of using this untreated water because of possible contamination. But, as the raw water which I am recommending for condenser purposes never comes in contact with either air or water which is returned to the system and, consequently is not brought in contact with people, there need be no fear from this source. Then, the only other question that might arise would be that of the wastage of this condenser water to the sewers.

When it is considered that water for condensing purposes is one of the major factors in influencing the use or non-use of air conditioning, and when it is considered that the raw water which I have advocated for the purpose of condensing is the cheapest method of condensing that I know of, it can be seen that if such lines were run for this purpose, the use of air conditioning combined with refrigeration would increase rapidly and satisfactorily in the future.

Place Air Intake to Avoid Pulling In Dust

By J. M. Pettingell*

THE location of the outside air intake for an air conditioning system frequently lacks sufficient consideration of probable sources of fumes, odors and airborne solids; consequently troubles develop which could be avoided by more careful planning and investigation. Complete information should always be obtained about nearby domestic or industrial activities producing a gas, vapor, odor or dust which might be objectionable if drawn into the system.

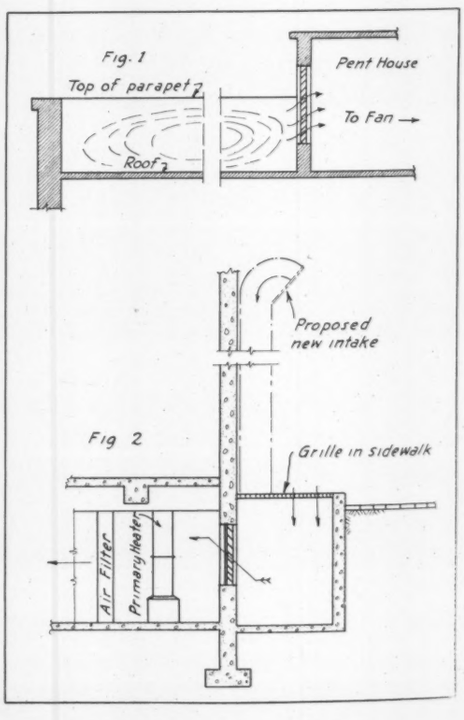
Intakes should be above ground level, removed from dust which is blown along the ground by winds. If the wind is strong, dust clouds may be visible, but much dust is so fine that it cannot be seen. Grilles in the sidewalk or at ground level and intakes through basement windows should be avoided.

Roof penthouse intakes should be higher than the parapet wall around the roof to avoid the dust, ash and soot which settle in such basins. Where there are nearby chimneys discharging smoke, ash and cinders from combustion and the cleaning of boiler tubes, a large quantity of dust is collected on the roof. This dust circulates around the roof and only a small amount may be blown over the parapet wall. If the intake is lower than the parapet much of this dust will finally be drawn into the system. Another disadvantage of a low penthouse intake occurs on hot summer days when the air absorbs heat from the hot roof. See Fig. 1.

Intakes in pits, areaways, passageways between buildings and from rear alleys are undesirable, as such places are natural collecting points for dust. Hazardous conditions may even result, as was the case in a theater installation where the janitor made a practice of burning waste paper, programs and sweepings in an alley. The outside air intake was at street level in the same alley and once smoke and burning particles were pulled into the system and distributed over the auditorium. Considerable damage was done but fortunately the theater was not occupied at the time.

The best location for an intake is on the side of a building above the level of wind blown ground dust and with no roofs or horizontal surfaces extending in front from which accumulated dust and heated air can be drawn into the system. The intake should not be so high that it is in the direct path of smoke from neighboring chimneys. It also should be removed from other sources of dust, fumes or odors, which under normal prevailing winds would reach the intake.

Sometimes the intake is not in the best position because of appearance. In the installation shown in Fig. 2, it was decided to place the intake below grade with a grille in the sidewalk of an alley. It was known this would cause heavy dust conditions but no other arrangement seemed suitable. The amount of dirt, soot, fumes from automobiles, cigarette stubs and other refuse which has entered the intake has been enormous. A fine mesh screen was placed at the entrance, the areaway has been swept clean every other day, but after five years, the primary heater coils have deteriorated so much from the unusual conditions that they must be replaced. When this is done, it is also proposed to elevate the intake by erecting a sheet metal duct on the outside wall of the building as shown.



*American Air Filter Co., Inc., Boston, Mass.

Apartment House in London Completely Air Conditioned

By J. W. Harvey*

Each of the 30 apartments of the Eaton House, in the heart of London's West End, has its own air conditioning plant . . . . . Condensing units were installed on platforms extended from the landings in the building well adjacent to the kitchen of each apartment

THE complete air conditioning of all apartments in the new eight story Eaton House in the heart of London's West End presented several problems which may be of interest to American engineers. The building, just a few yards from Hyde Park and adjacent to several large West End hotels, occupies what is considered one of the most valuable pieces of property in the world. It is practically complete, and is being decorated in preparation for the return of London society in October. The apartments have from three to six bedrooms, maids' quarters, and commodious living rooms and dining rooms. Rentals are from 415 to 1250 pounds per year.

The outstanding feature is, of course, the fact that it is the first block of luxury apartments in England to be completely air conditioned, summer and winter. The building contains 30 apartments, each of which has an entirely separate air conditioning plant.

Choosing the Type of System

In studying the air conditioning of a building of this type, several questions immediately arose, chief among these being the question of a central plant or separate units. In a building with a variety of tenants, each with his own personal ideas of what constitutes comfort conditions, it seemed wise to install a system which provided considerable latitude in the matter of individual control. In addition, should any of the flats be unoccupied for any length of time, it would be unnecessary and uneconomic to have them air conditioned.

One solution was to install separate air conditioners for each apartment, the cooling being supplied from a central water cooling system in the basement, but this would have entailed a large amount of pipe work to feed the various coolers, and also a continuously running water pump, the cost of running being borne by the management. It was the management's wish that, as far as possible, the conditioning of each flat be kept entirely separate so that each tenant could be charged independently for the operating costs of his installation. It was also thought an entirely independent plant would be most favorably received.

After careful study of these problems it was decided to install an entirely separate system for each of the 30 apartments. Each plant consists of one 1½ hp "Freon" condensing unit working in conjunction with a vertical air conditioner comprising slow speed fan and motor, heating coil, cooling and dehumidifying coils, air filter and winter humidifying spray. There are two large "wells" in the center of the building, built mainly for light and to house the fire escape staircase. The condensing units were fixed in these areas, each machine being adjacent to the kitchen of the apartment served.

The air conditioners were placed vertically in the kitchens of each flat and occupy a floor space approximately 3 ft by 2 ft. These were encased in sound proof enclosures, the latter being treated to harmonize with the kitchen equipment. Owing to the proximity of the condensing units, very short liquid and suction lines were required, thus greatly reducing the possibility of leaks.

The conditioners each handle 1300 cfm, representing about 12 changes per hour in the apartments. Each conditioner is supplied with hot water from the central boiler plant which serves in addition the various staircases and unconditioned corridors, and also provides hot water for baths and domestic purposes.

Air distribution was another problem, because the restrictions applying to the height of buildings in London operate to reduce ceiling heights so that it was not possible to provide false ceilings to conceal the duct-work.

An air delivery duct is carried from each conditioner, at a high level, with branches to each room. Wherever possible, use was made of cupboards and service space to house these ducts, and where this could not be done, the ducts were designed and treated with expanded metal and plaster to represent beams.

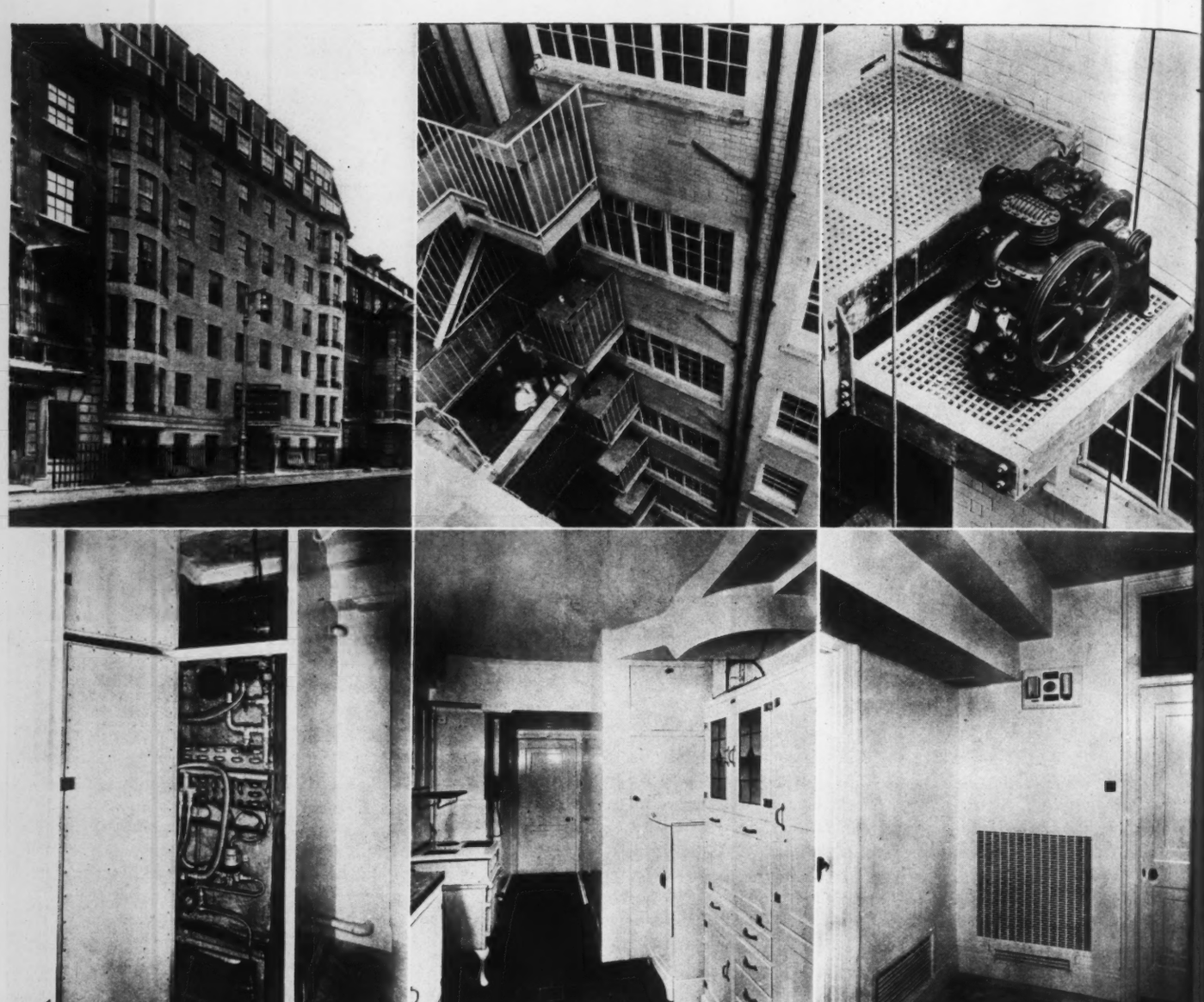
Each branch terminates in a diffuser grille at a high level in the room. The return air is taken from the hall of each apartment, grilles being fitted at a low level in each of the rooms, so that no direct duct connection is necessary and maximum floor space is preserved.

Control is Fully Automatic

The plant is under fully automatic control at all times, and in addition the tenant may vary the conditions as desired to suit his requirements. The controls are situated on an instrument board in the hall, and consist of a thermostat, a humidistat and a change-over rotary switch from cooling to heating or *vice versa*.

If, as often occurs in the early summer and autumn,

*York-Shipley, Ltd., London, England.



Left to right, top row—London's first completely air conditioned apartment building, the Eaton House . . . . . Condensing units in one of the two open wells . . . . . Condensing unit being installed; note method of mounting. *Left to right, bottom row*—The air conditioner for each apartment is installed in an enclosure in the kitchen . . . . . One of the kitchens, showing how air conditioner was built in and duct work concealed . . . . . Control panel in the hall of one of the apartments and return grille

cooling has been necessary during the day and the tenant finds that the evenings tend to be cold he can, by changing the rotary switch from cooling to heating and setting the thermostat at the desired point, cut out the compressor and open the automatic hot water valve. It is unnecessary to send a service man to effect the change-over because, owing to the arrangement of the equipment, the refrigerant in the evaporator is not affected by the heat from the heating coil when the latter is in operation.

Silent Operation Essential

As the equipment is in operation 24 hours per day, one of the greatest problems encountered was that of making the plant not only commercially silent, but *absolutely* silent in operation. This was accomplished by mounting the condensing units on pedestal type anti-vibrators which are fixed on a perforated iron grille supported on a steel platform extended from each landing. The air conditioners were mounted on compressed felt pads, the fan and motor being insulated from the conditioner casing with compressed felt washers. The duct work was designed for low velocities, and sound absorbent baffles were fitted where necessary.

The complete installation presents a neat and compact appearance, the duct work being hidden and the conditioners so concealed that they are not apparent in the kitchens.

Vern O. Knudsen* reviews recent developments here and abroad in noise measurement and control, with particular reference to heating and air conditioning

The War on Noise

THE war on noise has many fronts. In Germany, as in the United States, important contributions have been made in recent years to our basic knowledge of sound, noise, and hearing, new units of measurement have been approved or standardized, improved techniques of measurement have been devised, and equipment and methods of treatment to promote quiet operation have been developed.

Dr. Karl W. Wagner, Director of the Heinrich Hertz Institute for Vibration Research, described some months ago German developments in the war on noise in a technical paper in the *Zeitschrift des Vereines Deutscher Ingenieure*. Because heating and air conditioning engineers have manifested a wholesome interest in the problems of noise and its measurement and control, it is felt that the present review of progress made in Germany as well as in this country will be of benefit.

Standards of Noise Measurement

German workers in acoustics have accepted, for the most part, the tentative standards proposed by the *American Standards Association's* sectional committee on acoustical measurements and terminology. In agreement with our present usage, they use 1000 cycles as the reference frequency, and define the loudness level of a noise as the equally loud reference tone. Thus, if I, p are the intensity and root mean square pressure, in the direction of the normal to the wave front, of the equally loud 1000 cycle tone, and I_o, p_o are the threshold values, then the loudness level of the noise is

$$\text{Loudness level} = 10 \log_{10} \frac{I}{I_o} = 20 \log_{10} \frac{p}{p_o} \text{(Phon)}$$

Most German workers use "Phon" for this logarithmic unit of loudness level, where we use "decibel" (db), but a number of recent workers are using the name "decibel." The threshold values of I_o, p_o used in Germany differ about 3.8 db from those adopted in the United States. The Germans use $p_o = 3.16 \times 10^{-4}$ dynes per sq cm for the threshold pressure, which makes a loudness level of 70 db correspond to $p = 1$ dyne per sq cm, whereas we use $I_o = 10^{-16}$ watts per sq cm, or $p_o = 2.07 \times 10^{-4} \sqrt{(H/76)\sqrt{273/T}}$ dynes per sq cm, *where* H is the barometric pressure in cm of Hg, and T is the temperature in deg Centigrade. This means that a noise meter calibrated according to present American practice will read about 3.8 db higher than a similar meter calibrated according to present German practice.

The Fletcher-Munson curves of *equal loudness level* and their curve of *loudness vs. loudness level* are generally accepted in Germany. See Figs. 1 and 2. Everyone interested in noise measurements should be familiar with the general significance of Fig. 2. Thus, if a loudness level of 50 db is assigned an arbitrary loudness of 2000 units, it is found that a loudness of 4000 units

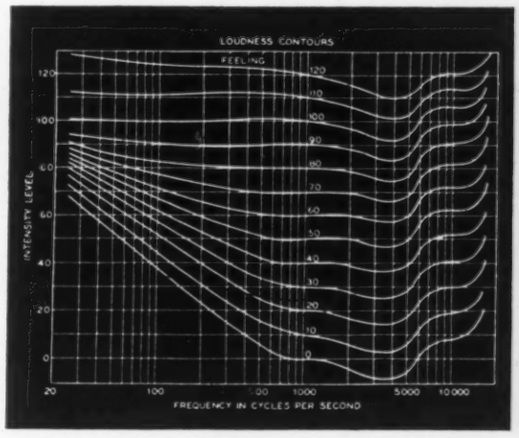


Fig. 1—Curves of equal loudness contour for pure tones (Fletcher and Munson)

(*i.e.*, a doubling of the loudness) corresponds to a loudness level of 60 db, and a loudness of 1000 units (*i.e.*, a halving of the loudness) corresponds to a loudness level of 42 db. Other relations between loudness and loudness level are given by Fig. 2.

Measurement of Impulsive Sounds

Several recent experiments have indicated that the brain responds to sound in a manner analogous to the response of a ballistic galvanometer. The loudness level of periodic impulsive sounds, such as the exhaust noise from a gas motor, depends upon the time integral of the sound intensity. Békésy has found that the ear responds to repeated impulsive sounds as though it had a "time constant" of 0.15 second. Steudel, following the

*University of California at Los Angeles.

work of Békésy, finds that when periodic impulses occur at a rate of 1 per sec there is an apparent increase in loudness level of 1 db, and when the rate is 50 per sec there is an apparent increase of 10 db, but no further increase for rates in excess of 50 per sec.

Meters for the measurement of such impulsive noises should simulate this ballistic characteristic of the hearing mechanism if the meters are to register what they are intended to register, namely, the "noisiness" of the noise. H. Sell of Siemens and Halske has developed a noise meter which is adapted to this function. The meter contains the usual high quality microphone and amplifier, but is followed by a so called *impulse tube*—a vacuum tube rectifier with a capacitance-resistance circuit in its input which gives the impulse tube a time constant of 0.15 second, so that its response to impulses will resemble the response of the ear and brain. The amplifier is coupled so that its amplification characteristic corresponds with the 80 db loudness level contour of Fig 1. In the output of the rectifier tube is a logarithmic meter calibrated in decibels, or a self registering meter may be substituted. By means of a potential divider in the input of the amplifier the sensitivity of the meter can be altered to give ranges of 55 to 80 db, 70 to 95 db, and 85 to 110 db. A convenient impulse generator of simple mechanical type, which develops an impulsive sound of constant intensity, can be attached to the microphone for calibrating and checking the sensitivity of the meter. The apparatus is housed in two boxes, one containing the microphone and amplifier and the other the indicating meter and batteries.

This meter represents a development of an instrument which is well adapted for its limited use of measuring impulsive noises such as traffic noise as well as the noise of many individual motors or rotating machines which develop periodic "puffs" or "slaps" or "knocks." Other meters can be developed to meet certain restricted purposes, but as yet no meter has been devised which is reliable for all kinds of noise. It is necessary only to consider the complicated nature of the ear response to realize the nature of the difficulties in the design of such a noise meter—such as the variation of sensitivity of the ear with frequency and intensity, the time constant of the ear, masking, fatigue, and the non-linear response of the ear to sound. Obviously, all these peculiar characteristics cannot be incorporated in a simple and an inexpensive noise meter.

Filters for Tubes and Ducts

Exhaust filters have been developed which, in the principles of design, are applicable to the problem of the reduction of noise transmission through pipes or ducts. Four methods have been used to prevent the transmission of sound through tubes: (1) acoustical filters of the Stewart low-pass or high-pass type—these are similar in principle to the well-known electrical filters composed of various combinations of inductance and capacitance—and are made up of a series of tubes and open or closed chambers which are inserted in the air or gas conducting pipe or duct; (2) interference tubes of the Quincke type—in general, these are similar to, but less effective than, acoustical filters; (3) the lining of the inner walls of the pipe or duct with a sound-absorptive material—often a duct is divided into a honey-comb structure with the sound-absorptive material so as to make the channels smaller and to increase the total amount of absorbing material; and (4) changes in the area of cross-section of the duct.

Method (3), and to a lesser extent method (4) are employed in heating and air conditioning installations and have been described previously in HEATING, PIPING AND AIR CONDITIONING. An interesting application of (1) is considered by Kluge in the case of the exhaust noise of a gas engine. He first calculates the noise of the explosions of a typical gas engine on the basis of classical gas and dynamical laws, and then determines the amount of attenuation or diminution which would be necessary to reduce this noise to 70 db at a distance of 5 meters. He finds that the attenuation should be 20 db at 100 cycles, increasing to 45 db at 3000 cycles. He then proceeds to design a low-pass acoustical filter of three sections which will provide approximately this required amount of attenuation. The unique feature of this filter is that the component chambers and connecting tubes are graded rather than uniform in size, and this is accomplished in such a manner as not only more closely to approximate the required attenuation characteristic but also to match the impedance of the filter to the alternating flow of gas through the exhaust system. In this way, the filter not only reduces the noise effectively but also increases rather than decreases the efficiency of operation of the engine. Although such a filter is not directly applicable to ordinary air ducts, the principles involved should prove valuable in the design of filters for ventilating ducts and pipes.

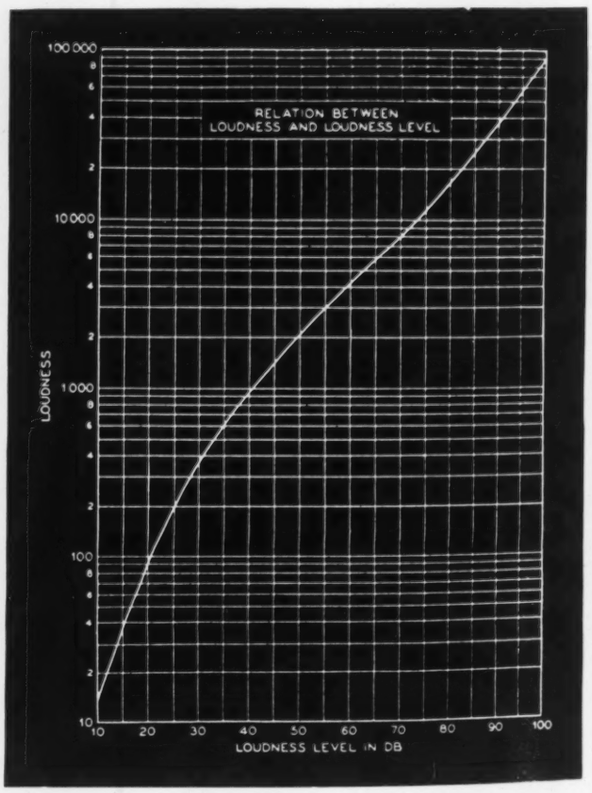


Fig. 2—This empirical curve between loudness and loudness level is useful for explaining to the layman how much noise reduction may be expected from proposed changes, such, for example, as inserting a sound filter in a ventilating duct (Fletcher and Munson)

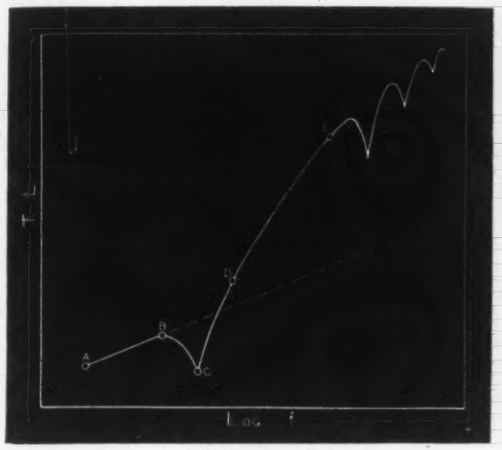


Fig. 3—Curve showing the transmission loss (*T.L.*) as a function of frequency for a double partition. The dotted line shows the *T.L.* for a single partition having the same weight as the double partition (After Wintergerst)

Transmission of Sound Through Walls and Small Openings

A single rigid partition offers resistance to the passage of sound waves almost wholly because of its mass, and the transmission loss (*T. L.*) is proportional to the logarithm of the mass per unit area of the wall, and increases linearly with the frequency of the sound. In the case of double partitions, with no rigid ties between them, Wintergerst obtains an equation for the ratio $\mathfrak{P}$ of the sound pressure in front of and behind the double partition,

$$\mathfrak{P} = \left[1 + i\omega \frac{m_1 + m_2}{Z_0}\right] \cos \gamma d + \left[\frac{Z}{Z_0} + \frac{i\omega m_1 (Z_0 + i\omega m_2)}{Z Z_0}\right] \sin \gamma d$$

where m_1 and m_2 are the masses per unit area of the two partitions, γ is the propagation constant (the real part of which gives the velocity of sound in the wall), Z is the characteristic impedance of the wall, d is the separation between the partitions, and ω is 2π times the frequency f.

The *T. L.* for such a double partition, calculated from Wintergerst's equation, depends upon the frequency in a manner indicated by Fig. 3. For low frequencies (*AB*) the insulation is the same as for a single partition of mass $m_1 + m_2$; the *T. L.* for such a single partition is indicated by the dotted line. The dip at *C* is attributable to panel resonance. *DE* increases much more rapidly than does the curve for a single partition, and it is in this range of frequencies that double partitions are especially effective—for the partitions used in buildings the resonant frequency *C* is as low as 50 cycles so that *DE* (and *EF*) cover the important range of frequencies ordinarily encountered in most problems of sound insulation.

It should be borne in mind, however, that the noises of many rotating machines used in heating and air conditioning are rich in low frequency components, and for such low frequencies double partitions offer no advantages over single partitions. The maxima and minima of the section *EF* result from the resonance of the column of air between the two partitions, and are determined by the distance *d*. Transmission measurements on a double partition (of thin wood) at the Heinrich Hertz Institute give results which accord quite satisfactorily with the Wintergerst theory. Gemant has recently extended this theory to apply to rigid, plastic, fluid, and porous materials.

It has long been known that sound, as is light, is diffracted when passing through small openings. The effect of diffraction, so far as sound transmission is concerned, is to increase the apparent size of the hole. Wintergerst and Knecht have calculated the effect for single circular holes, 3 to 12 cm in diameter, and obtain the following results, expressed in terms of

$$q = \frac{\text{apparent area of hole}}{\text{actual area of hole}}$$

f	100	200	400	600	800	1000	1400	1800
q	75	55	28	17	12	8	4	2.5

For several openings, with spacing large compared with the diameter of the hole but small compared with the wave length, the transmission increases with the square of the number of openings—in agreement with Rayleigh's theory.

Solid Borne Sound

Measurements of the velocity and attenuation or diminution of longitudinal, torsional and transverse vibrations in wood, concrete, brick and iron show that the attenuation increases linearly with the frequency, but that the actual attenuation is very small. Thus, in iron, a longitudinal vibration of 500 cycles must travel 1000 meters before the wave is attenuated 1 db. Torsional and transverse waves are more rapidly, but still slowly, attenuated. There is more, but still small, attenuation in wood, concrete and brick. Wood offers the greatest damping, the loss amounting to 1 db in 3 to 20 meters. This means, to the heating and air conditioning engineer, that solid-borne machinery vibration may travel through rigid structures great distances without appreciable loss of amplitude, and therefore steps must be taken to isolate or insulate such machinery no matter how far away may be the rooms where quiet is required.

Machine Noises

Progress has been made in determining and reducing the sources of noise of electric motors. It has been found that the alternating magnetic field of the armature sets up vibrations of the teeth and slots. The hum of these magnetically excited vibrations has been reduced as much as 20 db by redesigning the armature—breaking up the windings into two pairs of sections so that each pair produces mutually opposing magnetic fields on the teeth and thus minimizes the magnetic field which excites the teeth into vibration. By giving similar study to other sources of noise, both in motors and other machines, such as the vibration of the housings, resonance of plates, bars and air chambers, loose and eccentric parts, the action of commutators, the mounting of the machines on suitably designed flexible supports, and the housing of the machines in closed compartments, it is possible to reduce noise further.

In the plants and warehouses of Bayuk Cigars, Inc., over 60 air conditioning systems are in year 'round operation.

What the Operating Force Must Know for Effective, Efficient Air Conditioning

By Rush D. Touton*

IN every industrial activity there must be established a competent and trained personnel to insure its proper functioning. This has been overlooked to some extent in process air conditioning work, and, in my opinion, inadequate emphasis has been placed on the extremely vital point of operating the system to best advantage.

Operators tend to act on past experience and, for instance, may feel that a change of 3 to 4 F is the minimum which can be considered significant. In many industrial air conditioning applications, however, a variation of 1 F in a temperature reading may represent 15 per cent of the total work the system is capable of performing, and will have a similar effect on operating cost. Many operating men lack sufficient familiarity with factors such as dry bulb, wet bulb, and relative humidity, or with the manner in which they are changed by various conditioning processes, as for instance, by evaporative cooling.

A recently observed case was the full capacity operation of a 25 ton refrigeration unit supplying cold water to an air conditioner and maintaining a room dew point of 62 F during the month of December, and using no outside air, when the outside wet bulb temperature never exceeded 52 F. Air conditioning is naturally required to operate during periods of widely varying demand, and at least seasonally there occurs a complete reversal of heat and moisture flow through enclosing walls. An excellent opportunity for economy exists if the operator adjusts his equipment so that maximum use is made of the outside air, and if this air is excluded as much as possible when its condition is unsuitable.

Still another wasteful practice is the excessive use of heat to lower relative humidity, which is made necessary by carrying too high a dew point in the delivered air, thus causing not only a pyramiding effect which ultimately establishes a room dew point far too high for the best comfort and product condition, but possibly results in an excessive refrigeration demand.

Too often suitable instruments with which to gauge the functioning of the equipment are lacking, or when they are available they are not properly maintained or used. Notable in this regard is the common lack or poor condition of suction pressure gauges on refrigerating equipment, and of temperature indicators or recorders in conditioner inlets and outlets.

It therefore seems desirable that thorough provisions be made when an air conditioning plant is installed to assure, first, sufficient man power to care for the equipment properly, and second, to devote ample time to

*Technical Director, Bayuk Cigars, Inc., Philadelphia, Pa. Member of Board of Consulting and Contributing Editors.

training these men in the proper operation and maintenance of the equipment under all conditions for which the system is designed to operate. Operators of a year 'round conditioning system can by no means be considered experienced if the installation happens to be made in the summer and there are no instructions given for operation during the winter season.

Fortunately, the acquisition of adequate knowledge for best operation of these systems is attractive and, with the proper psychological approach the instructor will usually find his pupils most receptive. The best procedure is to discuss all previous methods and pet notions thoroughly, and then to take the course of modification and adaptation, rather than to disregard intrenched ideas. If at all possible, the operators should be selected in advance and urged to participate in the design; their familiarity with the product or local conditions is far too important to be neglected.

In most cases, whether the system is one designed primarily for comfort or for a better product, the resultant working conditions are improved. Recognizing that this can be the case, the operator will exert additional effort to provide the maximum of comfort for himself and fellow employees. Also, air conditioning is assuming increasing proportions as a full time activity, and this can be pointed out to accelerate the desire to learn about it. Again, unless the system is very large or the product a highly specialized one, no specific training in chemistry or other science is an absolute requisite; an aptitude for technical work is all that is necessary. Generally the men in charge of product conditions can be of material assistance in this educational program. Whether or not they were instrumental in the purchase of the equipment, they will be quick to appreciate and evaluate a simple demonstration, as proof of better output or employee health and comfort.

Some training of substitutes and assistants must not be overlooked. No one person can be counted on to be available constantly, and many systems are designed to operate on a 24 hour schedule.

Training Should Cover All Fundamentals

The program must cover all fundamentals controlled or affected by the equipment. Even the simplest installation will require an exposition and demonstration of its effects on dry and wet bulb temperatures, relative humidity, air change, air motion, and the manner in which the operation is to be changed to compensate for variations in outside weather. The way in which the heat retaining capacity of the enclosure or building affects the conditions should be covered.

If refrigeration is installed, a working knowledge of absolute humidity, sensible, latent and total heat of the air, and of the pressure-temperature characteristics of the refrigerant will be of value. A study of effective temperatures is distinctly worthwhile, and it should be suggested that the operator make careful observations on the physiological and psychological effects of the system as evidenced by reactions of other employees.

Operators should be advised that any indicating or recording instrument will require periodic calibration, and a plan should be made to facilitate this work and make it effective.

After a decision is made on the extent of the training required, it may be useful to suggest an outside form of study, such as a night school or correspondence course. In any event the reading of published material pertaining to the broad subject should be insisted upon. A variety of sources is available, and contemporary articles will extend knowledge and maintain interest.

No matter how extensive the system may be, the early training should include the repeated setting down in tabular form of all the factors the system controls and how it is accomplished (position of automatic or manual dampers, valves, etc., at the time readings are taken). By this method, a great many of the operator's questions will supply their own answers.

Information to Furnish Operating Crew

Aside from a complete description and object lessons, the designer or installer should supply the purchaser with the following material and other information as demanded by special conditions or design; this plan is employed by Bayuk Cigars, Inc.—makers of "Phillies" cigars—in whose plants and warehouses more than 60 air conditioning systems are in year 'round operation:

1. A full set of drawings and specifications and an assembly drawing of the entire system, with capacities of each part indicated. This may be diagrammatic but the parts should be numbered or marked in a standardized code system to correspond with the written instructions and index file.

2. A complete lubrication and service manual. This should include suggested materials to purchase or services to employ for maintenance and servicing since the owner is usually not equipped to care for annual overhauling, or major repairs on such parts as refrigerating machinery. This should include notes on the best times of the year to perform the necessary operation and data on effective clothing, gas masks, etc., as required.

3. A card index file—or material from which it can be prepared—showing the maker, model and full information on every purchased part, and complete details on material and construction of all portions fabricated by any contractor. This file will serve the double purpose of providing an accurate source of information for replacement parts, and a maintenance record.

4. A set of operation logs on which the operator may enter frequent observations of all essential factors during the initial training period and to record loads during any extremes of operation. The best seasonal intervals for setting up new load averages will be most valuable. If the designer cannot visit the plant for examination of these records, they should be mailed periodically and returned with instructive comment.

5. A set of design-service factors which can easily be set down against the operating logs. As an example, the operator should be given normal air pressure values at critical points, so that he may more readily check the air circulation and correct restrictions due to clogged heater fins and filters, or other obstructions. Here, also, the recording and evaluation of the relative humidity and the dry bulb and wet bulb temperatures, both in the delivered and room air, and the air change appear as a minimum requirement. In many cases the operator attempts or is expected to make the system perform an impossible duty, and these factors will establish that fact to the distinct advantage of the designer or installing contractor and the owner.

Air conditioning is a broad term covering many phases. Of course, for economic and other reasons, all installations are not designed nor intended to cover the application of all the phases to the particular case, and the training procedure must therefore be somewhat arbitrary. In any event, thorough information and assistance passed on from designer to operator will make for improvement in air conditioning results. The material required can be assembled during the design period with little expenditure of time or additional cost.

Air Conditioning for Health

THE effect of air conditioning on health and its uses in the treatment of diseases are considered by many to be the most important contribution of air conditioning to the future. While this aspect of the subject has not received the attention that industrial and commercial applications have been given, there is a growing appreciation of what the future of air conditioning may be in promoting health and happiness. Certainly, a great opportunity for serving humanity is offered.

In order to focus attention on what is now known of the medical and health aspects of air conditioning, and to stimulate thought on the future of such applications, contributions from authorities on the subject will appear regularly under this heading.

Air Conditioning Gaining Acceptance by Medical Profession

By C. P. Yaglou*

ABOUT 90 years ago John Gorrie, an eminent American physician and scientist, conceived of the possibilities of air conditioning as a therapeutic measure for the control of fevers in the South. He originated and designed a machine for making ice in order to cool the air in the rooms of the sick. Unfortunately, he did not live long enough to witness the progress in this field.

Today air conditioning is contributing much to the comfort and health of mankind substantially as visualized by Gorrie. It is gradually gaining acceptance by the medical profession as a preventive agent and a valuable aid in the treatment of certain diseases. Of first importance is probably the application to the institutional care of premature and other debilitated infants, where the maintenance of suitable temperatures with a high relative humidity, as determined by extensive research, resulted in a striking reduction of the incidence of respiratory diseases and gastro-intestinal syndromes,[1] with a consequent increase in the infant's chances for life.

In operating rooms, conditioned air is gradually becoming an indispensable aid in preventing explosions during operations and reducing the occurrence of post operative surgical shock in hot weather. It is now believed that in addition to the operating and sterilizing rooms, an adjoining small ward should also be conditioned as the collapse often occurs after removal of the patient from the operating room.

Such a conditioned ward would probably prove of great value in treating patients with heat stroke, fevers, summer diarrhea and other cases affected by high temperatures. The recent epidemics of heat stroke during the middle western droughts in 1934 and again this year are excellent illustrations of the desirability for providing suitable environmental control for emergencies. The most important application of this kind was probably the recent installation of air conditioning equipment in Italian hospital ships.

Excessive heat is the cause of much suffering but it also has some blessings. Artificial fever is often looked upon as a therapeutic measure in certain respiratory diseases, syphilis, some kinds of skin disorders, inflammatory rheumatism, chorea, and others. Of particular academic interest are the recent experiments of Walker on the possibility of destroying cancerous tissues in animals by the use of conditioned air. Conditioned air appears to offer a safer method of producing artificial fever than diathermy when it can be practically and economically applied. It is suspected that there is something injurious in the high frequency treatment, a condition which may be alleviated or avoided by the use of conditioned air.

In the treatment of pneumonia, respiratory, and heart affections, the importance of cool, dry air enriched with oxygen has long been recognized. Pollen asthma and hay fevers offer still a wider field of application, the main object here being adequate filtration of air.

Many other indications for conditioned air are now in the process of crystallization. Huntington, Besson, Mills and others have contributed much statistical evidence on the influence of weather and climate upon health and general welfare. More recently, Darier and Schmidt advanced independently the view that certain dermatoses[2] are the result of an interplay between a

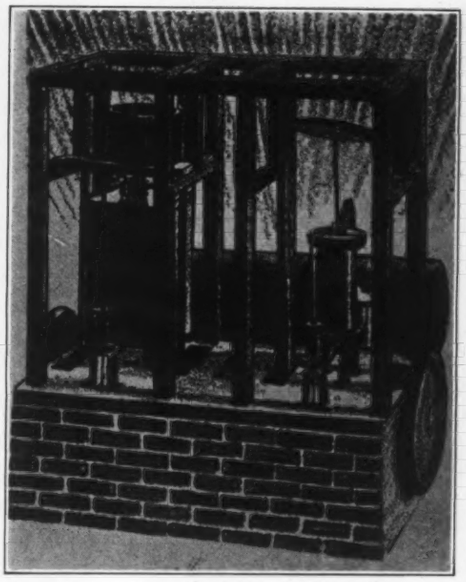
Dr. John Gorrie, who pioneered nearly 100 years ago in the application of air conditioning for health†

*Department of Industrial Hygiene, Harvard School of Public Health, Boston, Mass.

[1]A chain of symptoms in the stomach and intestine.—Ed.

[2]Skin diseases.—Ed.

†Reproduced through the courtesy of Dr. H. Marshall Taylor, author of "John Gorrie: Physician, Scientist, Inventor," published in *The Southern Medical Journal*, Vol. 28, No. 12.



Original model of Dr. Gorrie's ice machine.†

person's constitution and environment. Thomas, a scalp specialist, went a step further in attributing loss of hair to overheated dry air indoors in winter time. Although the connection is not far to seek, full scientific confirmation has yet to come.

In normal healthy persons conditioned air appears to be largely a matter of comfort, except under unusual circumstances. It is in susceptible individuals in whom continuous readjustments between the individual and his atmosphere may entail abnormal reactions and predisposition to disease. Eventually the resistance may be profoundly altered by the physical condition of the air and infection may set in. Kerr's inability to transmit the common cold from carriers to susceptibles in a properly conditioned room may be explained by the control of predisposing environmental factors. It does not necessarily lead to a denial of the generally accepted view that a cold is an infectious disease. Much more additional work is needed to prove Kerr's hypothesis that the common cold results from the inability of the body to adapt itself quickly to changes in temperature and humidity.

Progress in new therapeutic applications will and should be slow, as it must be preceded by intensive research to determine the range of optimum conditions for various diseases which are known to be affected by the physical condition of the air. The problem is a complex one owing to the enormous biological diversity of individuals and the widely different response to a given physical condition. The optimum air conditions in all instances would depend primarily upon the individual and only secondarily upon the type of disease.

Tunnel Air Cools Hotel Guest Rooms

Cool, washed air is supplied to 65 guest rooms of Chicago's John P. Harding Hotel by means of a recently installed system utilizing air taken from the extensive freight tunnel system many feet below street level. According to the Harding's chief engineer, the maximum temperature of the tunnel air is 64 F. This air is drawn through a 40 ft connection from the tunnel to an air washer and distributed to the guest rooms by a 35,000 cfm fan. Reheating coils, manually operated, are provided to give a measure of control over relative humidity, steam being turned on when the inside humidity becomes too high. A pump driven by a 5 hp motor recirculates the washer spray water. In the winter the same equipment supplies humidified air to the rooms.

According to Managing Director K. L. Williams, these 65 rooms have been received with a great deal of enthusiasm by the Harding's guests, and the number available has been entirely inadequate to meet the demand at the desk.

Adopt Standard Refrigeration Symbols

The refrigeration division of *N.E.M.A.* the *Refrigerating Machinery Association* and the *Air Conditioning Manufacturers' Association* have approved standard refrigeration symbols and submitted them to association members as "recommended practice" in connection with blueprint and general drafting work. This list of standard refrigeration symbols is not complete or final, the associations state in a joint release, but may be added to from time to time as desirability indicates. In this way, graphic layout presentations will be more standardized and more easily understood.

DISCONNECT SWITCH	DRIER	A.C. MOTOR
THERMOSTAT (SELF CONTAINED)	STRAINER	D.C. MOTOR
THERMOSTAT (REMOTE BULB)	HIGH SIDE FLOAT	ONE LINE / COMPLETE } FUSE
PRESSURESTAT	LOW SIDE FLOAT	COOLING TOWER
HAND EXPANSION VALVE	GAGE	EVAPORATIVE CONDENSER
AUTOMATIC EXPANSION VALVE	FINNED TYPE COOLING UNIT NATURAL CONVECTION	SOLENOID VALVE
THERMOSTATIC EXPANSION VALVE	PIPE COIL	PRESSURESTAT WITH HIGH PRESSURE CUTOUT
EVAP. SIDE EVAPORATOR PRESS. REGULATING VALVE THROTTLING TYPE	FORCED CONVECTION COOLING UNIT.	
EVAPORATOR PRESS. REGULATING VALVE THERMOSTATIC THROTTLING TYPE.	IMMERSION COOLING UNIT.	
EVAPORATOR PRESS. REGULATING VALVE, SNAP-ACTION VALVE	ICE MAKING UNIT	
COMP. SIDE COMPRESSOR SUCTION PRESSURE LIMITING VALVE. THROTTLING TYPE	HEAT INTERCHANGER	
HAND SHUT OFF VALVE	CONDENSING UNIT AIR COOL	
THERMAL BULB	CONDENSING UNIT WATER COOLED	
SCALE TRAP	COMPRESSOR	

Standard refrigeration symbols recently adopted

CONTROLS

By C. L. Ringquist*

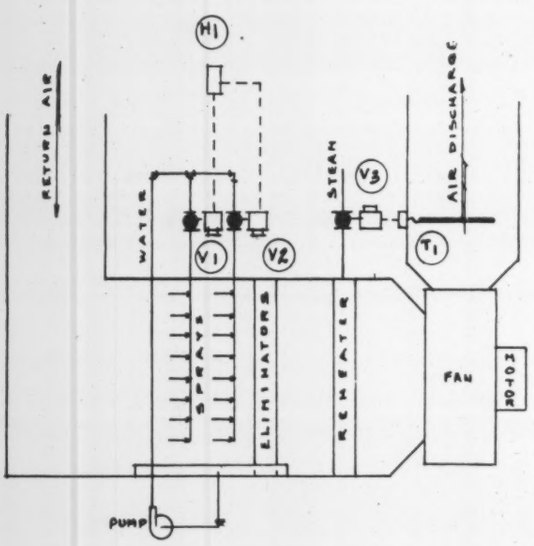
Reference Sheet 1

Although data on electrical controls for heating, humidifying, dehumidifying, ventilating, cooling and complete air conditioning may be had from numerous sources, information on groups of controls applicable to various types of systems is not so readily available. The author has therefore diagrammed typical control layouts, with each of which is given an explanation of the control cycle. . . . For the purpose of illustration, central fan coil types of systems are used; the control arrangements described are equally applicable to units built up to perform the same functions. . . . Types of systems covered by this series include humidifying; ventilating; heating and ventilating; heating, ventilating and humidifying; cooling, dehumidifying and ventilating; cooling, dehumidifying, ventilating and humidifying; heating, ventilating, dehumidifying and cooling; heating, ventilating, dehumidifying, cooling and humidifying; and zone control systems.

Humidifying

HUMIDIFICATION system control may be divided into two general classes, (1) by throttling or shutting off and turning on the sprays; (2) regulating the amount of heat supplied the incoming air or the spray water.

Humidity Control Accomplished by Throttling and Shutting Off and Turning on Humidifying Sprays:



Symbols

H_1 ..... Room humidistat
T_1 ..... Duct thermostat
V_1 and V_2 ..... On and off valves
V_3 ..... Modulating valve

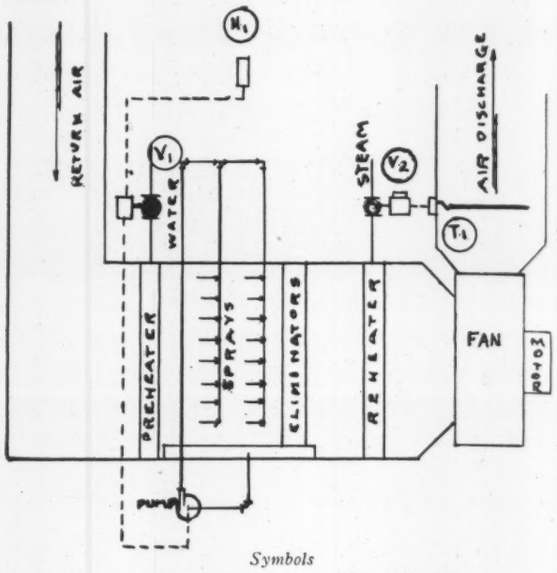
Cycle—H_1 controls operation of V_1 and V_2 in discharge spray water lines from circulating pump, acting to close V_1 on rising humidity and V_2 on further increase in humidity. The exact reverse happens on falling humidity.

T_1, in discharge air stream from fan, controls amount of steam supplied reheating coil, maintaining constant leaving air temperature by opening or closing V_3.

V_2 is equipped with auxiliary contact to shut off pump motor by means of a motor starter when both valves are closed. Fan and fan motor manually controlled.

*Air Conditioning Department, The Trane Co., La Crosse, Wis.

Heating Coil in Path of Incoming Air Raises Capacity of Air to Absorb Moisture:



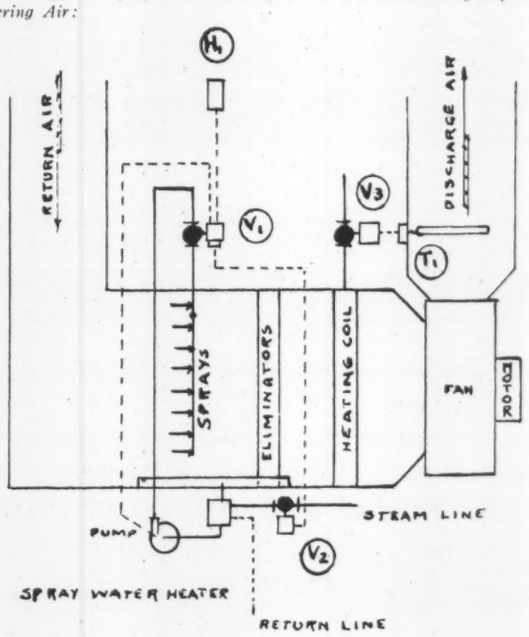
Symbols

H_1 ..... Room humidistat
T_1 ..... Duct thermostat
V_1 and V_2 ..... Modulating motorized valves

Cycle—H_1 controls V_1, allowing more or less steam to enter preheating coil as more or less humidity is required. V_1 is provided with an auxiliary contact which stops pump motor by means of a motor starter when humidity requirements are satisfied.

T_1, located in fan discharge, acts to control amount of steam allowed to enter reheating coil through V_2 located in the steam supply line to the reheating coil, thus maintaining constant temperature of air at fan discharge. Fan and fan motor operated manually.

Heat Supplied Spray Water to Increase Moisture Absorbing Capacity of Entering Air:



Symbols

H_1 ..... Room humidistat
T_1 ..... Duct thermostat
V_1, V_2, V_3 ..... Modulating motorized valves

Cycle—H_1 controls operation of V_1, in discharge line from circulating water pump, thus governing amount of spray water discharged through spray nozzles. V_1 is equipped with auxiliary contact for shutting off pump motor by means of a motor starter when V_1 is entirely closed.

V_2 in steam supply line to spray water heater, is controlled either by an auxiliary contact on V_1 which switches the humidity control to V_2 when V_1 is completely opened, or by means of a double coil in H_1 which modulates V_2 when V_1 is entirely opened.

T_1, in fan discharge, maintains constant leaving temperature by controlling amount of heat added to air passing through reheating coil by modulation of V_3 in steam line to coil. This system, as the two previously described, is not intended to supply any of the heating requirements of the humidified space.

Heating · Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

SEPTEMBER 1936

Table of Contents

The Specific Characteristics of Fans, by M. C. Stuart and J. B. Lusk 507
Performance Test of an Electric Hot Water Heating Boiler, by John James 512
Buffalo Adopts Comfort Air Conditioning Standards..... 519
A Bigger Program to Meet Research Needs..... 522
Study Courses in Heating, Ventilating and Air Conditioning 524
Candidates for Membership..... 528
Candidates Elected 530

The material in this Section is prepared by the Publication Committee of the Society and nothing that appears in it may be reprinted, either wholly or in part, without permission. The use of the Society's name for advertising promotions is never authorized.

OFFICERS AND COUNCIL 1936

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
51 Madison Ave., New York, N. Y.

President.....G. L. LARSON
First Vice-President.....D. S. BOYDEN
Second Vice-President.....E. H. GURNEY
Treasurer.....A. J. OFFNER
Secretary.....A. V. HUTCHINSON

COUNCIL

G. L. LARSON, *Chairman*
D. S. BOYDEN, *Vice-Chairman*

One Year
M. C. BEMAN, O. W. OTT, JOHN HOWATT, L. W. MOON, W. A. RUSSELL

Two Years
ALBERT BUENGER, F. E. GIESECKE, W. E. STARK, J. F. McINTIRE

Three Years
R. C. BOLSINGER, S. H. DOWNS, C. M. HUMPHREYS, W. L. FLEISHER

COMMITTEES OF THE COUNCIL

Executive: JOHN HOWATT, *Chairman*
L. W. MOON, M. C. BEMAN

Finance: J. F. McINTIRE, *Chairman*
E. H. GURNEY, D. S. BOYDEN

Meetings: ALBERT BUENGER, *Chairman*
F. E. GIESECKE, C. M. HUMPHREYS

Membership: W. A. RUSSELL, *Chairman*
R. C. BOLSINGER, W. L. FLEISHER

ADVISORY COUNCIL

John Howatt, *Chairman;* Homer Addams, R. P. Bolton, W. H. Carrier, S. E. Dibble, W. H. Driscoll, H. P. Gant, John F. Hale, L. A. Harding, H. M. Hart, C. V. Haynes, E. Vernon Hill, J. D. Hoffman, W. T. Jones, D. D. Kimball, S. R. Lewis, Thornton Lewis, J. I. Lyle, J. R. McColl, D. M. Quay, C. L. Riley, F. B. Rowley, F. R. Still and A. C. Willard.

COOPERATING COMMITTEE

A. S. H. V. E. Representative on *National Research Council:* Prof. F. E. Giesecke (1 year).

SPECIAL COMMITTEES

Committee on Admission and Advancement: E. N. Sanbern, *Chairman (one year)*; E. J. Ritchie (*two years*), and T. H. Urdahl (*three years*).

Publication Committee: M. C. Beman, *Chairman (one year);* A. I. Brown (*two years*), and F. C. McIntosh (*three years*).

Committee on Constitution and By-Laws: R. H. Carpenter, *Chairman;* O. W. Ott and W. E. Stark.

Guide Publication Committee: J. H. Walker, *Chairman;* Albert Buenger, S. H. Downs, C. H. B. Hotchkiss, W. H. Severns, and E. N. McDonnell, *Advisory.*

F. Paul Anderson Medal Award Committee: D. S. Boyden, *Chairman;* John Howatt, F. C. McIntosh, F. B. Rowley, and W. E. Stark.

NOMINATING COMMITTEE

Chapter	*Representative*	*Alternate*
Cincinnati	H. E. Sproull	J. J. Braun
Cleveland	M. F. Rather	C. F. Eveleth
Illinois	J. H. Milliken	J. J. Hayes
Kansas City	C. A. Weiss	L. A. Stephenson
Manitoba	C. H. Turland	J. E. Yates
Massachusetts	W. A. McPherson	W. T. Jones
Michigan	Thomas Chester	G. H. Tuttle
Western Michigan	J. H. Van Alsburg	S. H. Downs
Minnesota	C. E. Gausman	N. D. Adams
New York	W. W. Timmis	E. J. Ritchie
Western New York	W. E. Voisinet	B. C. Candee
Oklahoma City	F. X. Loeffler	E. F. Dawson
Ontario	M. W. Shears	H. H. Angus
Pacific Northwest	Lincoln Bouillon	E. O. Eastwood
Philadelphia	H. H. Erickson	M. F. Blankin
Pittsburgh	R. J. J. Tennant	F. C. McIntosh
St. Louis	R. J. Tenkonohy	J. W. Cooper
Southern California	W. E. Barnum, Jr.	Leo Hungerford
Washington, D. C.	L. S. Ourusoff	T. H. Urdahl
Wisconsin	E. A. Jones	Ernest Szekely

COMMITTEE ON RESEARCH

W. A. DANIELSON, *Chairman;* C. E. LEWIS, *Vice-Chairman;* F. C. HOUGHTEN, *Director;* DR. A. C. WILLARD, *Technical Adviser;* O. P. HOOD, *Ex-Officio Member. One Year:* C. A. BOOTH, E. K. CAMPBELL, JOHN HOWATT, A. J. NESBITT, J. H. WALKER. *Two Years:* C. A. DUNHAM, W. L. FLEISHER, ELLIOTT HARRINGTON, A. P. KRATZ, H. C. MURPHY. *Three Years:* W. A. DANIELSON, C. E. LEWIS, D. W. NELSON, CYRIL TASKER, C.-E. A. WINSLOW.

Executive Committee: W. A. DANIELSON, *Chairman;* C. E. LEWIS, A. P. KRATZ.

Finance Committee: G. D. KINGSLAND, *Chairman;* C. V. HAYNES, A. R. HERSKE, E. N. MCDONNELL, T. H. URDAHL.

Technical Advisory Committees - 1936

Committee on Air Cleaning Devices: H. C. Murphy, *Chairman;* M. I. Dorfan, S. R. Lewis, G. W. Penney, D. C. Simpson, W. O. Vedder.

Committee on Air Conditions in Relation to Comfort: C. P. Yaglou, *Chairman;* J. J. Aeberly, R. R. Sayers, C.-E. A. Winslow.

Committee on Air Conditioning in the Treatment of Diseases: Dr. E. V. Hill, *Chairman;* N. D. Adams, J. J. Aeberly, John Howatt, A. P. Kratz, V. L. Sherman, E. L. Stammer.

Committee on Air Conditioning Requirements of Glass: M. L. Carr, *Chairman;* A. N. Finn, R. A. Miller, F. W. Parkinson, W. C. Randall, G. B. Watkins.

Committee on Atmospheric Impurities and Resulting Safety and Health Requirements: Theodore Hatch, *Chairman;* J. J. Bloomfield, C. A. Booth, Philip Drinker, Dr. Leonard Greenburg, H. B. Meller.

Committee on Comfort Requirements for Summer Cooling: W. L. Fleisher, *Chairman;* A. E. Beals, F. R. Bichowsky, Thomas Chester, F. E. Giesecke, Elliott Harrington, Dr. E. V. Hill, R. E. Keyes, Cyril Tasker, C. P. Yaglou.

Committee on Corrosion in Air Conditioning Equipment: A. E. Stacey, Jr., *Chairman;* M. L. Diver, M. S. Kice, F. L. LaQue, C. E. Lewis, R. M. Palmer, F. N. Speller, C. M. Sterne, R. T. Thornton, J. H. Young.

Committee on Corrosion in Heating Systems: J. H. Walker, *Chairman;* E. L. Chappell, W. H. Driscoll, C. A. Dunham, L. B. Miller, R. R. Seeber, C. M. Sterne.

Committee on Direct and Indirect Radiation with Gravity Air Circulation: M. K. Fahnestock, *Chairman;* H. F. Hutzel, J. P. Magos, J. W. McElgin, J. F. McIntire, D. W. Nelson, R. N. Trane, T. A. Novotney.

Committee on Effect of Entering Temperature and Velocity on Temperature and Distribution of Air Within an Enclosure: Ernest Szekely, *Chairman;* S. H. Downs, M. K. Fahnestock, D. W. Nelson, C. H. Randolph, J. E. Schoen, G. L. Tuve, J. H. Van Alsburg.

Committee on Frictional Resistance to Flow of Air in Small Ducts and Fittings: J. H. Van Alsburg, *Chairman;* C. A. Booth, S. H. Downs, R. D. Madison, L. B. Miller, L. E. Smith, C. M. Humphreys.

Committee on Heating and Cooling Requirements of Buildings: O. W. Armspach, *Chairman;* P. D. Close, W. H. Driscoll, H. M. Hart, P. E. Holcombe, V. W. Hunter, H. H. Mather, E. C. Rack, F. B. Rowley, R. J. J. Tennant, J. H. Walker.

Committee on Heat Transfer of Finned Tubes with Forced Air Circulation: F. B. Rowley, *Chairman;* H. F. Hutzel, C. E. Lewis, E. J. Lindseth, R. H. Norris, W. E. Stark, G. L. Tuve.

Committee on Insulation: L. A. Harding, *Chairman;* E. A. Allcut, J. D. Edwards, E. C. Lloyd, R. T. Miller, E. R. Queer, T. S. Rogers, F. B. Rowley, W. S. Steele, B. Townshend, G. B. Wilkes.

Committee on Psychrometry: F. R. Bichowsky, *Chairman;* C. A. Bulkeley, J. A. Goff, Dr. E. V. Hill, F. G. Keyes, A. P. Kratz, W. M. Sawdon.

Committee on Railroad Air Conditioning: A. I. Brown, *Chairman;* F. E. Giesecke, C. S. Leopold, S. R. Lewis, L. W. Wallace.

Committee on Refrigeration in Relation to Air Treatment: M. K. Fahnestock, *Chairman;* E. A. Brandt, John Everetts, Jr., Elliott Harrington, E. D. Milener, K. W. Miller, E. B. Newill, F. G. Sedgwick, J. H. Walker.

Committee on Sound in Relation to Heating and Ventilation: J. S. Parkinson, *Chairman;* C. M. Ashley, C. A. Booth, V. O. Knudsen, R. F. Norris, C. H. Randolph, J. P. Reis, F. R. Watson.

OFFICERS OF LOCAL CHAPTERS—1936

CLEVELAND: *Organized,* 1916. *Headquarters,* Cleveland, O. *Meets,* Second Thursday in Month. *President,* G. L. TUVE, Case School of Applied Science. *Secretary,* PHILIP COHEN, 407 E. Ohio Gas Bldg.

CINCINNATI: *Organized,* 1932. *Headquarters,* Cincinnati, O. *Meets,* Second Tuesday in Month. *President,* E. B. ROYER, 6635 Iris Ave. *Secretary,* K. W. SCHICK, 561 Reading Rd.

ILLINOIS: *Organized,* 1906. *Headquarters,* Chicago. *Meets,* Second Monday in Month. *President,* J. J. HAYES, 53 W. Jackson Blvd. *Secretary,* C. E. PRICE, 6 N. Michigan Ave.

KANSAS CITY: *Organized,* 1917. *Headquarters,* Kansas City, Mo. *Meets,* Second Monday in Month. *President,* C. A. WEISS, 1811 Troost Ave. *Secretary,* G. L. BLISS, 1410 Waldheim Bldg.

MANITOBA: *Organized,* 1935. *Headquarters,* Winnipeg, Man. *Meets,* Fourth Thursday in Month. *President,* J. B. STEELE, 184 Waterloo St. *Secretary,* C. H. TURLAND, 325 Centennial St.

MASSACHUSETTS: *Organized,* 1912. *Headquarters,* Boston. *Meets,* Second Monday in Month. *President,* JAMES HOLT, Massachusetts Institute of Technology, Cambridge, Mass. *Secretary,* JOHN TURNER, 285 Columbus Ave.

MINNESOTA: *Organized,* 1918. *Headquarters,* Minneapolis. *Meets,* Second Monday in Month. *President,* N. D. ADAMS, 220 Second Ave. S. W., Rochester, Minn. *Secretary,* J. E. SWENSON, 800 Hennepin Ave.

MICHIGAN: *Organized,* 1916. *Headquarters,* Detroit. *Meets,* First Monday after the 10th of the Month. *President,* R. K. MILWARD, 127 Campbell Ave., *Secretary,* G. H. TUTTLE, 2000 Second Ave.

WESTERN MICHIGAN: *Organized,* 1931. *Headquarters,* Grand Rapids. *Meets,* Second Monday in Month. *President,* L. G. MILLER, Mich. State College, E. Lansing, Mich. *Secretary,* E. I. ADAMS, 115 So. Pine, Lansing, Mich.

MONTREAL: *Organized,* 1936. *Headquarters,* Montreal, Que. *Meets,* Second Monday in Month. *President,* G. L. WIGGS, University Tower. *Secretary,* C. W. JOHNSON, 630 Dorchester St., W.

NEW YORK: *Organized,* 1911. *Headquarters,* New York. *Meets,* Third Monday in Month. *President,* G. E. OLSEN, 101 Park Ave.

WESTERN NEW YORK: *Organized,* 1919. *Headquarters,* Buffalo. *Meets,* Second Monday in Month. *President,* P. S. HEDLEY, Curtiss Bldg. *Secretary,* C. A. GIFFORD, 247 North Drive.

OKLAHOMA CITY: *Organized,* 1935. *Headquarters,* Oklahoma City, Okla. *President,* F. X. LOEFFLER, 1604 N. W. Fifth St. *Secretary,* E. W. GRAY, Box 1498.

ONTARIO: *Organized,* 1922. *Headquarters,* Toronto, Ont. *Meets,* First Monday in Month. *President,* THOMAS MCDONALD, 117 Peter St. *Secretary,* H. R. ROTH, 57 Bloor St. W.

PACIFIC NORTHWEST: *Organized,* 1928. *Headquarters,* Seattle, Wash. *Meets,* Second Tuesday in Month. *President,* S. D. PETERSON, 473 Colman Bldg. *Secretary,* D. C. GRIFFIN, Orpheum Bldg.

PHILADELPHIA: *Organized,* 1916. *Headquarters,* Philadelphia. *Meets,* Second Thursday in Month. *President,* W. F. SMITH, 422 Bryn Mawr Ave., Cynwyd, Pa. *Secretary,* H. H. ERICKSON, 804 Architects Bldg.

PITTSBURGH: *Organized,* 1919. *Headquarters,* Pittsburgh. *Meets,* Second Monday in Month. *President,* R. J. J. TENNANT, 435 Sixth Ave. *Secretary,* T. F. ROCKWELL, Carnegie Inst. Tech.

ST. LOUIS: *Organized,* 1918. *Headquarters,* St. Louis. *Meets,* First Tuesday in Month. *President,* C. R. DAVIS, 2328 Locust St. *Secretary,* R. J. TENKONOHY, 3650 Shaw Blvd.

SOUTHERN CALIFORNIA: *Organized,* 1930. *Headquarters,* Los Angeles. *Meets,* Second Tuesday in Month. *President,* LEO HUNGERFORD, 524 Loew's State Bldg. *Secretary,* H. M. HENDRICKSON, 5051 Santa Fe Ave.

WASHINGTON, D. C.: *Organized,* 1935. *Headquarters,* Washington, D. C. *Meets,* Second Wednesday in Month. *President,* W. A. DANIELSON, 2236 Munitions Bldg. *Secretary,* M. D. KICZALES, 3000 Connecticut Ave., N. W.

WISCONSIN: *Organized,* 1922. *Headquarters,* Milwaukee. *Meets,* Third Monday in Month. *President,* M. E. ERICKSON, 8405 W. Greenfield Ave., West Allis, Wis. *Secretary,* R. G. KOCH, 826 E. Wisconsin Ave.

The Specific Characteristics of Fans

By M. C. Stuart* (*MEMBER*) and J. B. Lusk** (*NON-MEMBER*), Bethlehem, Pa.

THE fundamental variables involved in the performance of a given type of fan are quantity, head, efficiency, size and speed. In all problems of fan selection the quantity and head are fixed by a definite external system requirement and the size and speed of the most suitable type are to be determined. The usual quantity-head characteristics, as illustrated in Fig. 1, showing the variation of quantity, head, and efficiency for a given type of fan when the size and speed are fixed, do not lend themselves to the direct solution of problems of this kind.

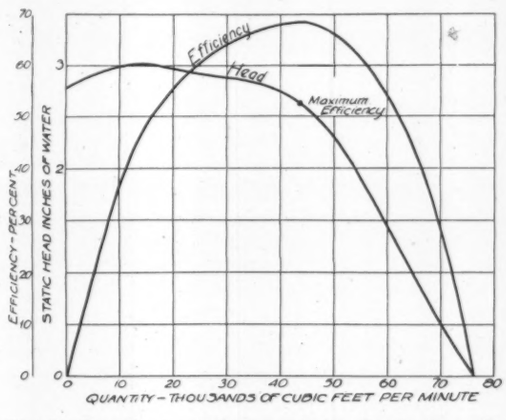


Fig. 1—Quantity-head characteristics of a fan type D, 72⅝ in. diameter, 400 rpm

It is the purpose of this paper to present a new system of fan characteristics, based upon the well-known fan laws which lend themselves to a direct solution of fan selection problems, serve to classify fans as to performance rather than form or design, and are directly useful in the solution of a great variety of fan application problems. These characteristics which are termed *specific characteristics* by the authors, are an outgrowth of the well-known specific speed functions which have been for a long time applied to hydraulic turbines, centrifugal fans and centrifugal pumps.

The basic feature of the specific characteristics of fans, or of other centrifugal machinery such as pumps, hydraulic turbines, propellers, etc., is that they show, for a given type of machine, the variation of size, speed and efficiency when the external system of the machine is fixed. In the case of fans, the specification or fixing of external system fixes the quantity and head of the fan. For fans, then, the specific characteristic would show the variation of size, speed and efficiency for a given type of fan when the quantity and head are fixed. The definitions of the new concepts required, and the explanation of symbols used are as follows:

Notation and Definitions

Q = quantity, thousands of cubic feet per minute.
h = head, inches of water.
e = efficiency, per cent.
D = maximum diameter at tip of blades, inches.
N = speed, revolutions per minute.
V = blade tip speed, feet per minute $= \dfrac{\pi D N}{12}$

D_s = specific diameter, inches $= D \dfrac{h^{\frac{1}{4}}}{Q^{\frac{1}{2}}}$

N_s = specific speed, revolutions per minute $= N \dfrac{Q^{\frac{1}{2}}}{h^{\frac{3}{4}}}$

V_s = specific tip speed, feet per minute, $= \dfrac{\pi D_s N_s}{12} = \dfrac{V}{h^{\frac{1}{4}}}$

The *specific diameter*, D_s, of any fan operating at a given efficiency is the diameter of a geometrically similar fan which, when running at its corresponding *specific speed*, N_s, will produce 1000 cfm at 1 in. head at the same efficiency.

The *specific speed*, N_s, of any fan operating at a given efficiency is the speed of a geometrically similar fan of a diameter D_s which will produce 1000 cfm at 1 in. head at the same efficiency.

The *specific tip speed*, V_s, of any fan operating at a given efficiency is the tip speed of a geometrically similar fan with diameter D_s and speed N_s at the same efficiency.

The expressions for specific diameter and specific speed,

$$D_s = D \frac{h^{\frac{1}{4}}}{Q^{\frac{1}{2}}} \text{ and } N_s = N \frac{Q^{\frac{1}{2}}}{h^{\frac{3}{4}}},$$

are derived in Appendix I from the well-known fan laws which state the variation of quantity and head with diameter and speed when operating at a constant efficiency.

The expression for specific tip speed,

$$V_s = \frac{\pi D_s N_s}{12} = \frac{\pi D N}{12\, h^{\frac{1}{4}}} = \frac{V}{h^{\frac{1}{4}}}$$

follows from the definition and the expressions for specific diameter and specific speed.

Specific Characteristics

The basis for the computation of the specific char-

*Professor Mechanical Engineering, Lehigh University.
**C. Kemble Baldwin Research Fellow, Lehigh University.
For presentation at the 43rd Annual Meeting of the American Society of Heating and Ventilating Engineers, St. Louis, Mo., January, 1937.

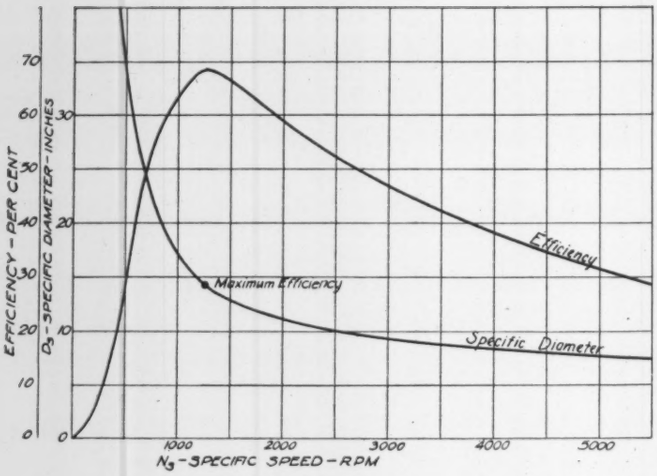


Fig. 2—Specific characteristics of a fan, type D

acteristics of a fan type is the data from a test of a certain fan of that type as portrayed by the quantity-head characteristic curves. Simultaneous values of quantity, head and efficiency are selected from the curves and the corresponding values of D_s, N_s and V_s are computed.

The details of the computation of the specific characteristics in Fig. 2 from the quantity-head characteristics of Fig. 1 are given in Appendix II. The specific characteristics of Fig. 2 presented in this manner show the functional relations between D_s, N_s, and e in contrast with the functional relations of Q, h, and e as shown by the quantity-head characteristics of Fig. 1. Just as the characteristics of Fig. 1 show variation in quantity and head with speed and size fixed, so the *specific characteristics* of Fig. 2 show variation in size and speed with quantity and head fixed.

From the quantity-head characteristics of Fig. 1, the quantity and head for fans of the same type but of other sizes and speeds may be easily determined by the well understood application of the usual fan laws. In a similar manner, from the *specific characteristics* of Fig. 2, the size and speed for fans of the same type required to produce various quantities and heads may be easily determined by the application of the specific diameter and specific speed coefficients. The details of these determinations are given in another part of this paper. The two curves of Fig. 2 are the only curves actually required to present the entire specific characteristics of a fan type. Other curves between the various specific functions are desirable, however, to develop the maximum utility of the specific characteristic method in fan classification, selection and in fan problems. The curves presented in this paper are the following:

a. Specific diameter vs. efficiency, shown in Fig. 3 for a group of 8 fan types.

b. Specific speed vs. efficiency, shown in Fig. 2 for one fan type and in Fig. 4 for a group of fan types.

c. Specific tip speed vs. efficiency, shown in Fig. 5 for a group of fan types, and

d. Specific speed vs. specific diameter shown in Fig. 2 for one fan type and in Fig. 6 for a group of fan types.

The designations of the 8 types of fans for which the specific characteristics were computed and plotted in Figs. 3, 4, 5, and 6 are given in Table 1.

Table 1—Fan Type Designations

Type	Description	Source
A	Forward curved blade	Fan catalog
B	Forward curved blade, double inlet	Fan catalog
C	Radial blade, double inlet	Fan catalog
D	Backward curved blade	Fan catalog
E	Radial blade, narrow	Fan catalog
F	8 blade airplane propeller fan	Ohio State Engineering Experimental Station, *Bulletin* No. 77
G	Axial flow fan	*A.S.M.E. Transactions* Oct. 1935
H	Slight backward curved blade, narrow	Fan catalog

In all problems of fan selection the quantity and head are fixed by a definite external system requirement and the diameter and speed of a fan of the most suitable type are to be determined. From the formulas for specific speed and specific diameter, it is seen that for definite values of quantity and head, the actual diameter of a fan is proportional to its specific diameter and the actual speed is proportional to its specific speed. It is also observed that any quantity and head could be produced by any type fan, within certain limits, if it is the proper size and runs at the proper speed.

Other considerations in the problem which cause limitations are efficiency, actual tip speed, actual speed or actual diameter. A fan is usually selected to operate at or near its best efficiency. This efficiency requirement will limit the corresponding values of D_s and N_s and therefore the values of the actual diameter and speed, for a given type of fan. In many cases the tip speed is limited by the degree of quietness required in operation, and in others by the strength of the parts. The use of synchronous and induction motors directly connected to fans limits the actual speeds at which the fans will operate. Space limitation is the least common restriction placed upon fan selection, but in some cases it does definitely limit the diameter of the fan to be installed.

When tip speed is a limiting factor, the specific tip speed may be computed from the formula

$$V_s = \frac{V}{h^{\frac{1}{2}}}.$$

From Fig. 6 it may be seen that certain fan types are at once eliminated from consideration. The remainder of the problem is to select from the available types, the one which is most suitable as to size, speed and efficiency to perform the required service.

When the speed at which a fan must run is fixed, the specific speed becomes definitely established, because in these cases N, Q and h are all fixed. This fixing of the specific speed limits the choice of fan types to those having good efficiency at the known specific speed. The diameters required of each type can now be computed from the specific diameters corresponding to the specific speed.

When the diameter of the fan is fixed, the specific diameter is fixed because D, Q and h are all fixed. This fixing of the specific diameter limits the choice of fan types to those having good efficiency at the known specific diameter. The speed at which each type must run may be computed from the specific speeds correspond-

ing to the specific diameter. An example in fan selection is given in Appendix III.

The Classification of Fans

For a fixed quantity and head the fan speed must be directly proportional to the specific speed and the diameter directly proportional to the specific diameter. Further, specific speed and specific diameter are functions of efficiency, and the values of specific speed and specific diameters at maximum efficiency become significant because of the fixed ratio of the specific characteristics to the actual. The wide variations in the values of N_s and D_s at best efficiency for fans of various types are shown on Figs. 3 and 4. Specific tip speeds are significant at the best efficiency because the actual tip speeds of various fans producing the same head bear the same proportion to their respective specific tip speeds.

A tabulation of the values of N_s, D_s and V_s for the 8 fan types at the best efficiency, is given in Table 2.

Table 2—Best Efficiency Tabulations for 8 Fan Types

Fan Type	A	B	C	D	E	F	G	H
Best efficiency	67.7	67.2	68.5	68.7	58.0	46.2	70.4	71.5
N_s	900	1180	900	1270	580	4900	2000	310
D_s	11.5	8.7	14.2	14.2	22.0	11.0	15.3	4.3
V_s	2700	2700	3350	4720	3240	14100	8000	3500

Fig. 3 which shows the relation between specific diameter and efficiency for several types of fans serves to classify fans according to relative diameter at best efficiency for a given service. Thus fans A, B, and F may be classified as small fans, and E and H as large fans.

Fig. 4 which shows the relation between specific speed and efficiency for several types of fans, serves to classify fans according to the speed at the best efficiency. Fans E and H may be classified as low speed fans, and G and F as high speed fans for the same service. Propeller fans, Type F, have extremely high specific speeds.

From the expression $D = D_s \frac{Q^{\frac{1}{2}}}{h^{\frac{1}{4}}}$, it may be seen that fans producing relative large quantities D_s must be small in order to have a small actual diameter. When there is space limitation the fan having the smallest D_s will give the smallest D.

From the expression $N = N_s \frac{h^{\frac{3}{4}}}{Q^{\frac{1}{2}}}$ it is evident that fans operating against relatively high heads must have a low N_s to keep the speed low. For fans producing a large quantity with respect to head, the N_s must be high to keep the actual speed reasonable. For high speed turbine drive N_s must be high and for low speed engine

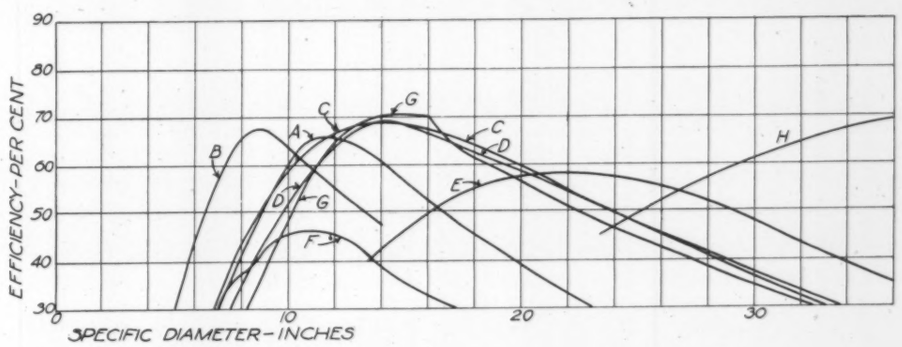


Fig. 3—Specific diameter vs efficiency for various fan types

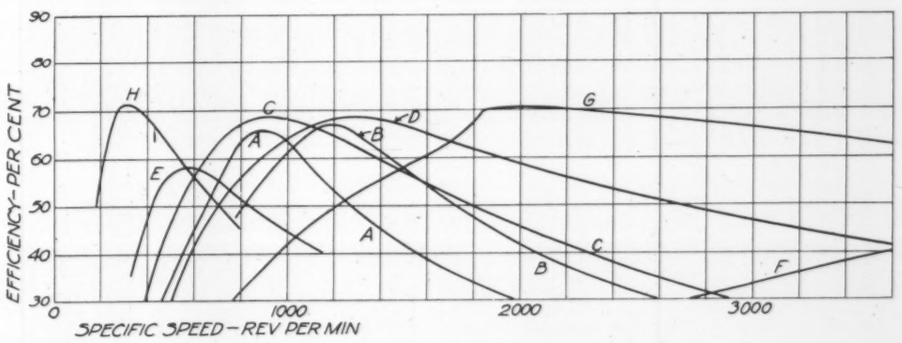


Fig. 4—Specific speed vs efficiency for various fan types

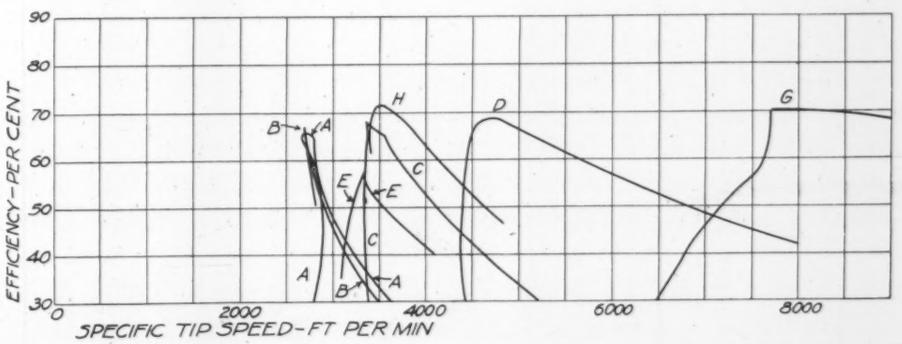


Fig. 5—Specific tip speed vs efficiency for various fan types

drive N_s must be low for the same service. The diameter is not affected as much by the head as is the speed.

Specific tip speed, V_s, may also be used as a basis for fan classification. The specific tip speed is independent of the quantity requirement as shown by the expression $V = V_s\ h^{\frac{1}{2}}$. High head fans must have low V_s in order to not have excessive actual tip speeds.

Fans which produce high heads and small quantities must have low N_s and high D_s for the speed to be moderate, such as E and H.

Fans which produce large quantities at low heads must have a high N_s and low D_s such as Fan G.

In addition to their utility in fan classification and selection, the specific characteristics are useful in solving a wide variety of problems in fan application. The methods of the solution of several types of problem are suggested in Appendix IV.

Appendix I

Derivation of Expressions for N_s and D_s

The fan laws may be expressed as follows:

$$Q = C_1 N D^3 \qquad (1)$$

$$h = C_2 N^2 D^2 \qquad (2)$$

$$e = \text{constant}$$

To show the variation of N as affected by quantity and head, D may be eliminated from the equations (1) and (2):

$$N = C_3 \frac{h^{\frac{3}{4}}}{Q^{\frac{1}{2}}} \qquad (3)$$

When $h = 1$ and $Q = 1$, $N = C_3$; or, C_3 is the speed of a fan required to produce 1 in. head and 1000 cfm. This is the specific speed N_s of the fan.

$$N = N_s \frac{h^{\frac{3}{4}}}{Q^{\frac{1}{2}}} \qquad (4)$$

and

$$N_s = N \frac{Q^{\frac{1}{2}}}{h^{\frac{3}{4}}} \qquad (5)$$

To show the variation of D as affected by quantity and head, N may be eliminated from the equations (1) and (2):

$$D = C_4 \frac{Q^{\frac{1}{2}}}{h^{\frac{1}{4}}} \qquad (6)$$

When $h = 1$, and $Q = 1$, $D = C_4$; or C_4 is the diameter of a fan required to produce 1 in. head and 1000 cfm. This is the specific diameter D_s of the fan.

$$D = D_s \frac{Q^{\frac{1}{2}}}{h^{\frac{1}{4}}} \qquad (7)$$

and

$$D_s = D \frac{h^{\frac{1}{4}}}{Q^{\frac{1}{2}}} \qquad (8)$$

Appendix II

Computations for Specific Characteristics

The basis of computations for the specific characteristic of Fig. 2 for fan type D is the data from a test of a 72⅝ in. fan of type D running at 400 rpm.

The items of Table 3 and the source of each are as follows:

Item 1 = Static efficiency, per cent, from curve Fig. 1 corresponding to Q.

Item 2 = Quantity discharged, thousands of cubic feet per minute, selected from curve Fig. 1.

Item 3 = Static head, inches of water, from curve Fig. 1, corresponding to Q.

Item 4 = (Item 2)$^{\frac{1}{2}}$

Item 5 = (Item 3)$^{\frac{1}{4}}$

Item 6 = (Item 3)$^{\frac{3}{4}}$

Item 7 = Specific Speed; $N_s = \dfrac{NQ^{\frac{1}{2}}}{h^{\frac{3}{4}}} = \dfrac{400 \times \text{Item 4}}{\text{Item 6}}$.

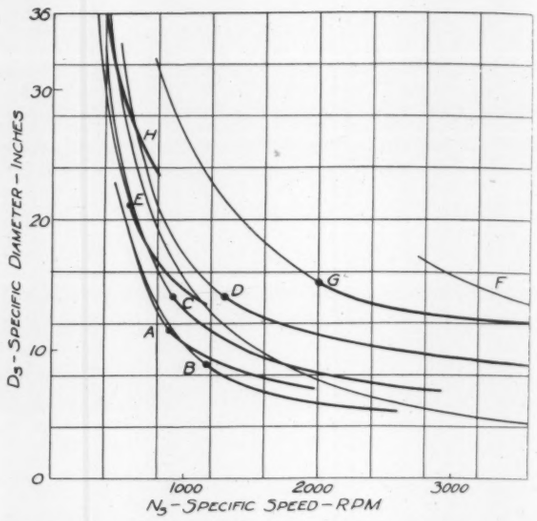


Fig. 6—Specific speed vs specific diameter for various fan types, showing point of maximum efficiency

Item 8 = Specific Diameter; $D_s \dfrac{Dh^{\frac{1}{4}}}{Q^{\frac{1}{2}}} = \dfrac{72.625 \times \text{Item 5}}{\text{Item 4}}$

Item 9 = Specific Tip Speed; $V_s = \dfrac{\pi N_s D_s}{12} = \dfrac{\pi \times \text{Item 7} \times \text{Item 8}}{12}$.

Appendix III

Problems in Fan Selection

It is required to select a type, speed and size of a fan to produce at least 25,000 cfm at a head of 4 in. of water at a good efficiency. The tip speed should not exceed 7000 fpm for quietness.

Solution:

Maximum specific tip speed, $V_s = \dfrac{V}{h^{\frac{1}{2}}} = \dfrac{7000}{2} = 3500$ fpm

From Fig. 5 it will be noted that types D and G are eliminated from consideration because in these types specific tip speed is excessive.

A comparison as indicated in Table 4 of the size, speed and tip speed at best efficiency for various types to give the re-

Table 3—Specific Characteristic Computation Values.

Item Number								
1	2	3	4	5	6	7	8	9
e	Q	h	Q	h	h	N_s	D_s	V_s
18.9	5.0	2.90	2.236	1.305	2.223	403	42.4	4470
36.2	10.0	2.98	3.162	1.314	2.270	557	30.2	4400
48.5	15.0	3.00	3.873	1.316	2.281	679	24.7	4390
55.5	20.0	2.96	4.472	1.312	2.257	793	21.3	4420
60.3	25.0	2.92	5.000	1.307	2.235	895	19.0	4450
63.8	30.0	2.89	5.477	1.304	2.218	987	17.3	4470
66.6	35.0	2.83	5.915	1.297	2.183	1083	15.9	4510
68.3	40.0	2.75	6.325	1.288	2.136	1185	14.8	4590
68.7	45.0	2.58	6.710	1.267	2.035	1320	13.7	4730
66.2	50.0	2.29	7.071	1.230	1.861	1520	12.6	5030
61.3	55.0	1.89	7.415	1.172	1.612	1840	11.5	5540
54.1	60.0	1.45	7.746	1.097	1.312	2343	10.3	6300
43.6	65.0	0.96	8.060	0.990	0.970	3320	8.9	7550
27.8	70.0	0.50	8.367	0.841	0.595	5630	7.3	10760
6.5	75.0	0.10	8.660	0.562	0.178	19470	4.7	24000

quired quantity and head may be used to select the type. Use the formulas $N = N_s \frac{h^{\frac{3}{4}}}{Q^{\frac{1}{2}}}$, $D = D_s \frac{Q^{\frac{1}{2}}}{h^{\frac{1}{4}}}$, $V = \frac{\pi DN}{12}$, with N_s and D_s determined from curves of Fig. 6.

Type B has the smallest diameter, 30.8 in. All the fans will operate within the limit of tip speed. Types E and H would have relatively large diameters.

If the speed is limited to 600 or 720 rpm

$$N_s = 600 \frac{(25)^{\frac{1}{2}}}{(4)^{\frac{3}{4}}} = 1060 \text{ or } N_s = 720 \frac{(25)^{\frac{1}{2}}}{(4)^{\frac{3}{4}}} = 1270$$

From Fig. 4:

At $N_s = 1060$

A, 61 per cent efficiency
B, 64 per cent efficiency
C, 67 per cent efficiency

At $N_s = 1270$

A, 50 per cent efficiency
B, 65.5 per cent efficiency
C, 62.5 per cent efficiency

Fan C at 600 rpm, from Fig. 3. $D_s = 12.5$, efficiency = 67 per cent.

Fan B at 720 rpm, $D_s = 8.1$, efficiency = 65.5 per cent.

Fan C would have to be much larger than fan B by the ratio $\frac{12.5}{8.1}$.

If D were limited to 27 in.

$$D_s = 27 \frac{(4)^{\frac{1}{2}}}{(25)^{\frac{1}{2}}} = \frac{27 \times 1.414}{5} = 7.64$$

Table 4—Comparative Fan Selection Values.

Fan Type	A	B	C	E	H
Best e	65.7	67.2	68.5	58.0	71.5
N_s	900	1180	900	580	310
D_s	11.5	8.7	14.2	22.0	43.0
N	510	668	510	328	176
D	40.7	30.8	50.2	77.8	152
V	5440	5390	6700	6680	7000

From Fig. 3:

Fan B would be the only fan which would give a good efficiency 62 per cent.

Appendix IV

Problems in Fan Application

1. Given type of fan, Q and h. To find size, speed and power required for best efficiency.

a. From Fig. 4, N_s vs e curve, find N_s at best efficiency.
b. From Fig. 6, N_s vs D_s curve, find D_s corresponding to N_s for that type of fan.
c. Solve for N and D from N_s and D_s functions.
d. Compute power from Q, h, and e $\left(P = \frac{0.1573Qh}{e}\right)$

2. Given type of fan, Q and h. To find diameter, efficiency and power for a given speed.

a. Compute N_s from N_s function.
b. From Fig. 4, N_s vs e curve, find efficiency.
c. From Fig. 6, N_s vs D_s, find corresponding D_s.
d. Solve for D from D_s function.
e. Compute power from Q, h, and e.

3. Given type of fan, Q and h. To find speed, efficiency and power for a fan with given diameter.

a. Compute D_s from D_s function.
b. From Fig. 3, D_s vs e curve, find efficiency.
c. From Fig. 6, N_s vs D_s, find corresponding N_s.
d. Solve for N from N_s function.
e. Compute power from Q, h, and e.

4. Given type, diameter and speed. To find Q and h at best efficiency.

a. From Fig. 6, N_s vs D_s, find N_s and D_s at best efficiency.
b. Solve for Q from fan law, i.e. $Q = \left(\frac{N}{N_s}\right)\left(\frac{D}{D_s}\right)^3$
c. Solve for h from fan law, i.e. $h = \left(\frac{N}{N_s}\right)^2 \left(\frac{D}{D_s}\right)^2$

Interest in Wood Chemistry

Attention being given today to the chemistry of wood was brought before the *National Lumber Manufacturers Association*, at its recent annual meeting, in an address by J. W. Watzek, Jr., retiring president.

The Forest Products Laboratory of the U. S. Forest Service, Madison, Wis., ceaselessly devotes its attention to the interesting problems of the physical and chemical adaptation and conversion of wood to the multitudinous requirements of modern life. A fact which is drawing chemical research into the cellulose field is that trees and wood are spontaneously reproducible and, therefore, practically inexhaustible.

The Forest Products Laboratory has not yet made wood gas a project, but it is advanced in the study of the extraction of ethyl alcohol from wood for fuel and power purposes. It is reported that ethyl alcohol can be produced today by known processes from cheap coniferous wood with a yield of 20 gal per cord and at a cost not exceeding 20c a gallon. This is of significance in the event of a depletion of petroleum supplies with a resulting increased cost for gasoline.

Mr. Watzek, however, referred to gas produced directly from wood as the motor runs, and stated that it is this possibility of deriving power from wood and wood waste for the operation of both stationary and locomotive engines that has stimulated the research of governments and scientists in countries lacking in petroleum.

The economic sanctions recently applied to Italy resulted in marked stimulation of the use of wood gas motors in that country. The self-containment policies of Germany have greatly increased the use of producer gas automobiles, and similarly in Austria. France has been developing the wood-gas engine for many years and has a number of trucks equipped with gas-producer apparatus. Extensive and successful trials were made in this country of the French device as long as 5 years ago. Operatively the tests were successful, but the cheapness of gasoline in this country, in view of its superiorities over wood gas, has prevented its general introduction.

Valuing wood at $6 a cord of 2,000 lb, and gasoline at 20c a gallon, it was found in one of the army tests that producer gas resulted in a cost of two-thirds of a cent per hour per horsepower as against a cost of two-and-one-half cents for gasoline. The wood gas apparatus can be used on a regular gasoline motor and in at least one of the tests the engine had both wood gas and gasoline carburetor attachments. In comparing gasoline and wood gas, it was found that gasoline produces more rapid acceleration and starts more easily than the wood gas. A cord of wood propels a vehicle for about 325 miles. One of the disadvantages of the wood gas engine is that it takes several minutes to start the generation of the combustible gas. Another is the space required for wood storage and the plant, and it does not have the pickup and quick get-away of gasoline.

In the event that in the course of time petroleum supplies should become scarce and costly, and with the improvements that can be expected in the preparation and application of wood gas, the United States with its illimitable forests would be relatively as well equipped as now for internal combustion engine fuel.

Performance Test of an Electric Hot Water Heating Boiler

By John James* (*MEMBER*), New York, N. Y.

ALTHOUGH many designers of heating and air conditioning equipment have recognized for a number of years the meritorious features of a system incorporating electrical heat supply, little has been definitely accomplished in this field because of the high immanent operating charges. Design factors which have also tended to restrict this type of development have been the corrosion problem of the electric heating elements, and attempts to design a unit of high thermal efficiency.

It is the purpose of this paper to discuss the features of an electric heating boiler which was recently designed, built and placed in a residence having a hot water radiator system and to report the test results of this unit over a limited period of operation.

Description of Installation

The electric boiler unit is connected to a heating system in a nine room residence having overall dimensions of 25 by 40 ft shown in Fig. 1 and located in Utica, New York. To provide suitable living accommodations for an additional family, the building had been reconditioned on the second floor. The exterior walls of the house are constructed of clapboard, sheathing, studs and plaster with no insulation. The second floor rooms are finished on the interior side walls and ceiling with rigid insulation. The home has a full basement constructed of concrete walls and floor. No weatherstripping is provided for any of the windows and although storm windows are available on the east bedroom of the second floor, they were not placed in a closed position during the entire period of test.

Previous to the installation of the electric unit a round, cast-iron sectional boiler heated the two-pipe gravity hot water radiator system. The cast-iron boiler was arranged for burning coal using hand-firing with no automatic control equipment. The actual cast-iron radiation installed in the residence amounts to 505 sq ft.

Heat loss calculations of the building based on values given in THE A.S.H.V.E. GUIDE 1936 and as noted in Table 1 indicate that about 5 per cent more radiation is installed than actually required. Due to the fact that provisions were made later for heating the second floor, improperly arranged piping resulted in duplication of lengthy branch run-outs from the main flow and return piping located on the ceiling of the basement. However, this piping arrangement did not seem to impair the circulation of water to the several radiators. A large portion of the exposed piping in the basement is covered with 4-ply air-cell asbestos insulation.

An exterior view of the electric and the cast-iron boilers is shown in Fig. 2 indicating the general arrangement of connecting the new boiler to the present heating system.

Fig. 1—View of residence at Utica, N. Y.

Description of Electric Boiler

The design of the electric unit consists of two rolled concentric steel plates which are illustrated in Fig. 3 and arranged according to the cross-sectional diagram of Fig. 4. The unit is constructed so that a vacuum seal is provided between the two exterior shells, which completely enclose the heating section of the boiler. A view of the boiler top and bottom cover showing the vacuum space is illustrated in Fig. 5.

Heating Section

A photograph of the five cast-iron round heating sections is also indicated in Fig. 3. These sections are 3 in. square in exterior dimension and are made with a cored hole so that the walls of the element are approximately $\frac{3}{16}$ in. in thickness. Pressed fit nipples are used for connecting the sections and the entire group is compressed into place with two bolts extended and bolted through the two strap plates attached to the top and bottom of the heating system.

Electric Heating Elements

The several electric heating elements are placed in direct contact with the inside and outside surfaces of the heating section. Located in the inside and connected into one group are nine 500 watt (4.5 kw) elements and another group of fifteen 500 watt (7.5 kw) elements is located on the outside surface, resulting in a total rated capacity for all the elements of 12 kw. When both groups were connected to the 220 volt, 3 phase source

*51 Madison Ave., New York City.

Table 1—Calculated Heat Losses of Residence

First Floor		
Living Room	12,320	
Dining Room	6,192	
Kitchen	9,747	
Bed Room—west	5,490	
Bath	2,507	
Bed Room—south	4,858	
Bed Room—east	5,814	46,928
Second Floor		
Kitchen	7,670	
Bath	2,500	
Living Room	12,650	
Bed Room	7,620	30,440
		77,368 Btu per hour Total

Equivalent Cast Iron Radiation

$77{,}368 \div 160 = 483$ sq ft

Installed Radiation

First Floor	324
Second Floor	181
	505 sq ft Total

$\frac{505 - 483}{483} = 4.6$ per cent more installed radiation than calculated heat loss according to values given in THE A.S.H.V.E. GUIDE 1936.

of power supply, a meter test indicated that the elements had a capacity of 11.5 kw, thus indicating an appreciable line loss. A sheet metal casing holds the elements in position on the inside and outside surfaces, and furthermore, this casing acts as a conducting and radiating shield for dissipating the heat to the several cast-iron heating sections. In Figs. 6 and 7 are shown two views of the heating section with the electrical elements attached. The power supply lead wires are indicated in a position ready for insertion in the inner steel shell.

The unit is assembled so that connecting pipes to the two water outlets and inlets extend through the vacuum space with metal and fibre packing seals, thus reducing heat leakage from the interior space. Additional sealed openings from the inner space are provided for the two power supply wires and a small copper tube which is connected to the control equipment.

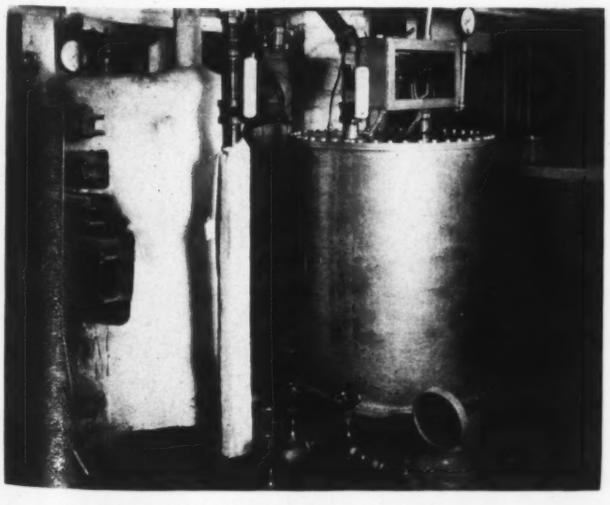


Fig. 2—Exterior view of electric boiler installation

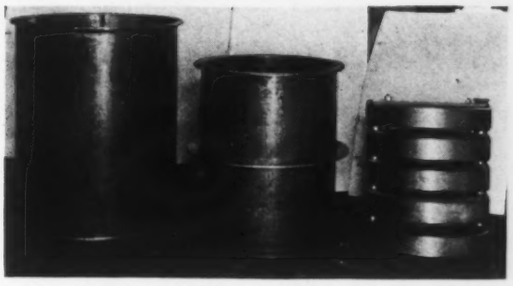


Fig. 3—View of outer and inner shells and heating section

Vacuum Pump

A vacuum in the sealed space is maintained with a small remotely located pump connected by a copper tubing to an outlet provided on the top of the outer boiler shell. The pump operates automatically over a range of from 15 to 20 in. Hg., and with a 1⅝ in. bore and 1⅜ in. stroke it has a displacement of 969 cu in. when operating at a speed of 340 rpm. The unit is belt driven from a 1/6 hp electric motor running at 1725 rpm.

Control Equipment

The control equipment for the unit is located at the top of the boiler as shown in Fig. 2. Arranged in the metal and glass encased cabinet are two typical sets of electrical contactors. A room thermostat located on the arch between the first floor living and dining rooms operates one set of contactors which control the group of 7.5 kw elements located on the outside surface of the heating section. A limit control switch located on the outside of the contactor case controls the group of 4.5 kw elements inserted on the interior surface of the heating section. The control bulb for operating the limit control switch is located near the inside center of the round heating section approximately equidistant from the top and

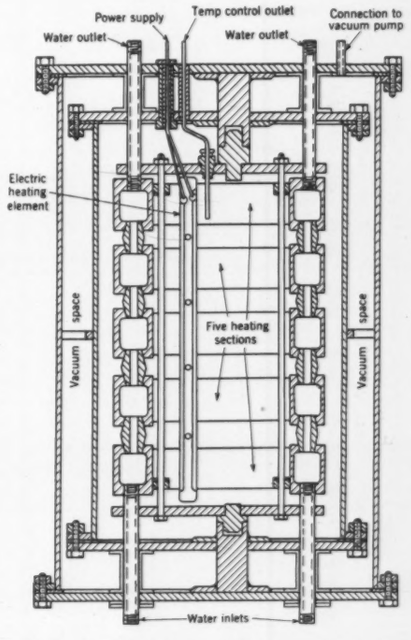


Fig. 4—Cross-sectional diagram of boiler unit

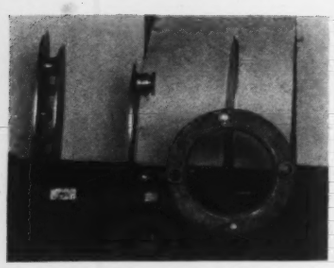


Fig. 5—View of boiler top and bottom cover showing vacuum space and one heating section

bottom. It is the function of the limit control switch to maintain a constant boiler water temperature and the room thermostat regulates the amount of additional heat generated to satisfy the inside temperature conditions.

Testing Apparatus

Indicating thermometers were provided for observing the boiler inlet and outlet circulating water temperatures. The limit control switch was provided with a temperature scale for determining the inside boiler temperature as well as a pointer for adjusting the control setting. Several indicating thermometers were located at various points in the living quarters on inside walls and away from windows for noting indoor room temperatures at regular intervals.

Outside temperatures were obtained from an automatic temperature recording instrument located on the premises of the local utility company's plant, approximately one mile from the residence.

A watt meter was connected in the power supply to the unit for recording graphically the actual electrical input. Space divisions on the chart were of ample width to observe small variations in the input as well as the period of time elapsed for any particular load. The meter was supplied by the local utility company and was accurately calibrated before installation on this particular test.

Results

On the morning of April 4, 1936, the conversion of the hot water heating system from the cast-iron coal fired boiler to the electric unit was commenced. At noon the revised installation was accomplished and shortly thereafter the power switch was turned on the cold heating system, which had been filled with 48 F water from the city main. When the electric boiler was started it was observed that the indoor temperature had dropped to an average temperature of 50 F and the corresponding outside temperature was approximately 32 F. Frequent readings were recorded during the first few hours of operation and it was noted that it required about 3½ hours for the electric boiler to raise the indoor temperature from 50 to 73 F.

Provisions were made at the start of the test to record the electrical input, but because of insufficient temperature data the period of the tabulated results shown in Table 2 covers a group of 25 days from April 7 to May 1, 1936.

It was noted that after the switch was turned on the boiler at noon on April 4, the unit operated continuously without interruption during the period of test. In view of the fact that this boiler was the first experimental unit built from the initial design, it was considered that this record of continuous operation without any revisions or previous testing was of particular significance.

Comfortable temperature conditions were maintained in the living rooms of the home over a 24 hour daily period during the complete test. Temperatures of approximately 72 to 74 F were desired by the family on the first floor and the room thermostat was set to maintain these conditions. The fact that the occupants on the second floor opened windows to obtain comfort indicated that a lower temperature was desired, which doubtless accounts for a higher electrical input during the period of test than actually required for the residence. On a basis of the recorded inside temperatures, the average temperature was calculated to be about 73 F.

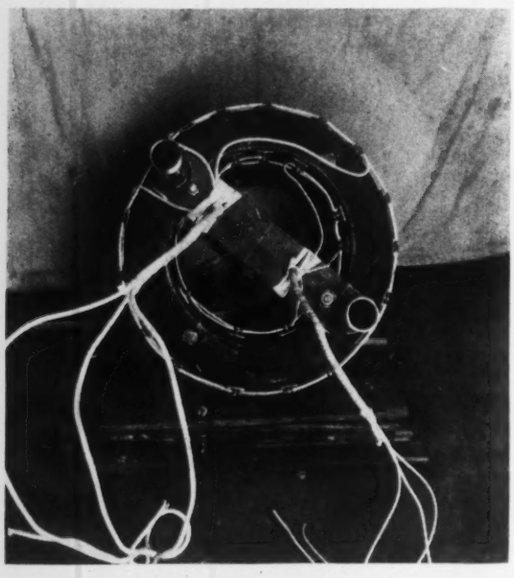


Fig. 6—Top view of heating section with electric elements in position

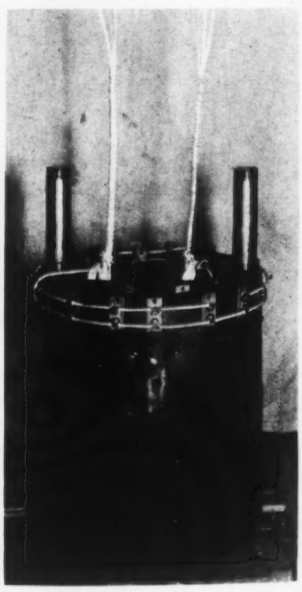


Fig. 7—Elevation view of heating section showing metal shield over electric elements

Table 2—Test Results of Electric Hot Water Heating System

Date	Time of Day	Ave. Outside Temp.	Ave. Deg. Temp. Diff. Day	General Weather Conditions	Inside Temp.		Boiler Limit Temp. Control	Circulating Water Temp.			Electrical Input Kwhr	Kwhr per Deg. Temp. Diff. Day
					Obs.	Ave.	Set'g.	Obs.	In	Out	Diff.		
April													
7	6 a. m.			Rain	70		240	190	88	112	24		
7	noon			and	72		240	198	89	113	24		
7	6 p. m.	37.6	35.4	Snow	70	70.7	240	200	108	136	28	198.7	5.62
8	6 a. m.				70		235	201	107	131	24		
8	noon			Snow	74		238	205	105	134	29		
8	6 p. m.	31.7	41.3		72	72.0	235	200	112	136	24	248.8	6.03
9	6 a. m.			Fair	72		240	220	115	140	25		
9	noon				74		240	210	112	132	20		
9	6 p. m.	38.5	34.5		74	73.3	230	200	102	125	23	204.8	5.93
10	6 a. m.			Fair	72		240	200	101	124	23		
10	noon			and	74		245	206	116	136	20		
10	6 p. m.	41.7	31.3	Rain	72	72.7	240	202	112	130	18	192.9	6.17
11	7 a. m.				70		230	205	108	127	19		
11	noon			Rain	73		230	210	112	131	19		
11	6 p. m.	44.0	29.0		74	72.3	230	203	100	119	19	167.7	5.78
12	8 a. m.				72		220	200	102	120	18		
12	noon			Fair	75		220	200	112	122	10		
12	6 p. m.	47.6	25.4		74	73.7	220	200	112	127	15	153.0	6.02
13	6 a. m.			Rain	72		220	195	105	118	13		
13	noon				74		220	200	109	122	13		
13	6 p. m.	46.3	26.7		73	73.0	220	196	108	120	12	142.1	5.32
14	6 a. m.			Rain	70		240	190	103	117	14		
14	noon				73		240	200	110	123	13		
14	6 p. m.	49.1	23.9		74	72.3	240	195	103	119	16	149.2	6.24
15	6 a. m.				71		240	190	103	117	14		
15	noon			Fair	70		240	196	106	120	14		
15	6 p. m.	51.5	21.5		73	71.3	240	190	102	116	14	124.1	5.78
16	6 a. m.				70		240	197	97	115	18		
16	noon				70		240	200	109	128	19		
16	6 p. m.	43.2	29.8	Snow	73	71.0	250	205	112	132	20	188.8	6.33
17	6 a. m.			Rain	72		240	205	117	136	19		
17	noon			and	73		240	201	114	132	18		
17	6 p. m.	38.7	34.3	Snow	74	73.0	240	200	116	136	20	206.4	6.02
18	7 a. m.				72		240	202	110	131	21		
18	noon			Rain	74		240	200	108	120	12		
18	6 p. m.	40.0	33.0		73	73.0	240	203	112	127	15	207.7	6.29
19	7 a. m.			Fair	72		240	200	90	110	20		
19	noon				74		240	203	93	112	19		
19	6 p. m.	43.6	29.4		74	73.3	240	205	101	115	14	173.3	5.89
20	6 a. m.			Fair	71		240	201	103	116	13		
20	noon			and	75		240	205	105	120	15	148.5	6.02
20	6 p. m.	48.3	24.7	Rain	74	73.3	240	195	112	139	27		
21	6 a. m.			Rain	72		240	212	117	132	15		
21	noon				72		240	201	115	130	15		
21	6 p. m.	43.2	29.8		72	72.0	240	198	117	133	16	171.0	5.73
22	7 a. m.			Fair	72		240	215	118	138	20		
22	noon			and	72		240	205	110	129	19		
22	6 p. m.	36.7	36.3	Snow	72	72.0	240	201	111	131	20	215.6	5.93
23	6 a. m.				72		240	210	117	136	19		
23	noon			Fair	74		240	197	100	121	21		
23	6 p. m.	43.6	29.4		72	72.7	240	199	95	115	20	164.8	5.60
24	6 a. m.			Fair	72		240	203	109	126	17		
24	noon				74		240	193	112	131	19		
24	6 p. m.	43.6	29.4		73	73.0	240	190	107	124	17	180.1	6.13
25	7 a. m.			Fair	72		240	204	106	130	24		
25	noon				74		240	185	94	116	22		
25	6 p. m.	45.8	27.2		72	72.7	240	183	90	110	20	157.5	5.79
26	8 a. m.			Fair	72		240	190	96	114	18		
26	noon				73		240	194	90	110	20		
26	6 p. m.	50.2	22.8		73	72.7	240	199	97	116	19	136.1	5.87
27	7 a. m.				72		240	201	106	120	14		
27	noon			Fair	72		240	190	90	110	20		
27	6 p. m.	48.7	24.3		72	72.0	240	192	92	111	19	144.2	5.94
28	7 a. m.				72		240	184	93	114	21		
28	noon			Rain	72		240	186	94	115	21		
28	6 p. m.	57.5	15.5		72	72.0	240	189	96	118	22	113.1	7.30
29	7 a. m.				72		240	193	101	120	19		
29	noon				78		180	170	97	118	21		
29	6 p. m.	67.3	5.7	Fair	80	76.7	180	163	96	117	21	66.2	11.61
30	6 a. m.				72		100	97	55	80	25		
30	noon				76		100	95	61	83	22		
30	6 p. m.	69.4	3.6	Fair	74	74.0	100	90	60	82	22	9.3	2.58
May													
1	6 a. m.				70		100	97	84	96	12		
1	noon				76		100	98	80	90	10		
1	6 p. m.	72.0	1.0	Fair	76	74.0	100	98	80	92	12	13.4	13.4

At the termination of the test the graphic chart which recorded the electrical input was removed and analyzed in detail. The daily power consumptions obtained from the chart are shown recorded in Table 2, and in Table 3 is given a detailed summary of the tabulated test results. A complete analysis of the periods of time at which the various electric elements were connected to the load are given in Table 4.

In Fig. 8 are plotted the daily electrical inputs in relation to the average outside temperatures which were obtained from the weather charts. It will be noted that when the curve is extended to zero heat consumption, it intersects the temperature line at approximately 72.5 F which checks closely with the calculated average inside thermometer readings. From this curve may easily be obtained the power consumption at any outside temperature, such as at 0 F, which is 428 kwhr per day.

The conversion of the daily power consumption to a basic factor for comparing and estimating daily and total seasonal loads was obtained by dividing the daily input by the differential between the average inside and outside temperature. The latter value is referred to in this paper as the degree temperature difference day. The only difference between this value and the degree-day is that the latter uses a common base of 65 F, whereas in this case the observed average inside temperature of 73 F is used for the base. In arriving at the original degree-day value of 65 F it was assumed that residential temperatures dropped at night, with the firing device generally not in operation, but in this case the unit was operating 24 hours a day. Theoretically the heat requirement of a building is proportional to the difference between the outdoor and indoor temperatures and it would seem that the factor

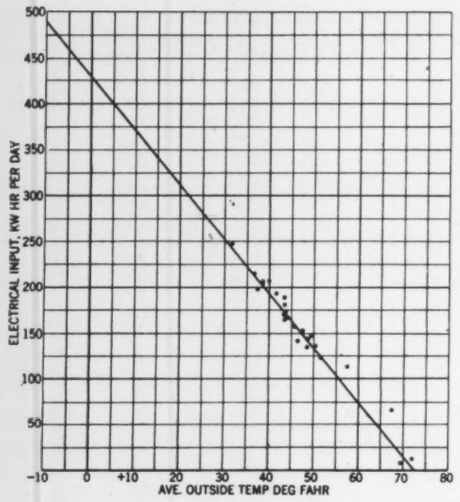


Fig. 8—Relation between electrical input and outside temperature

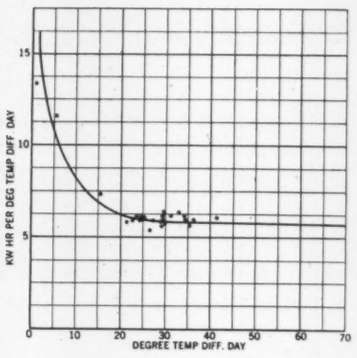


Fig. 9—Relation between electrical input per degree temperature difference day and degree temperature difference day

just described would provide a basic value for establishing comparative power consumption relationships.

In the last column of Table 2 are given the kilowatt hours per degree temperature difference day and in Fig. 9 are plotted these values against the basic factor. The shape of the curve corresponds in general to other curves showing the same relationship, indicating that erratic values of electric input per degree temperature difference day are obtained for small degree temperature difference days.

As previously referred to in Table 1 the calculated heat loss of the building was determined to be 77,368 Btu per hour, or 1,030 Btu per hour, per degree difference inside to outside temperature, based upon a 75 F temperature rise. The total number of degree temperature difference days obtained from Table 2 was found to be 645.2. Therefore, the estimated heat requirement for the 25 day period would be equal to $645.2 \times 1030 \times 24 = 15{,}980{,}000$ Btu. A summation of the electrical consumption for the same period of time totalled 3877 kwhr or 3,877,000 watthours, or the equivalent of 13,220,000 Btu per hour. From these results it indicated that the estimated heat requirement averaged about 20.9 per cent higher than the actual heat requirements of the building. This value is recognized as a safe heat loss computation percentage difference, due to the indeterminate outside weather variables and heating-up load factors. This difference is also comparable to a value of 23 per cent which was recently presented in a paper[1] to the Society.

Records of the U. S. Weather Bureau show that the average temperature in Utica for the normal heating season from October 1 to May 1 is approximately 35 F. Based on a normal design indoor temperature of 70 F the estimated number of degree temperature difference days in the heating season would be equivalent to $(70—35) \times 210 = 7350$. Using the total electric input for the 25 day period, the kilowatt hours per degree temperature difference day is equal to $3{,}887{,}000 \div 645.2 = 6.02$. The estimated kilowatt hour consumption per heating season would be 7350×6.02 or 44,250. Using this value and the present electric rate or any probable future rate based upon a greater load demand, the estimated cost per heating season could be obtained.

These estimates do not include the small power consumption of the pump which maintains a vacuum seal on the unit. Although no test data are available, it was observed by actual watch timing that the pump did not operate more than 10 min during a single day of operation during the test.

Sections of the chart record for electrical input are given in Figs. 10 and 12. The kilowatt hours per degree temperature difference day for the chart shown in Fig. 10 is 6.03 which is equal to the average value for the 25 day period and therefore is representative of an average condition. The average outside temperature is 31.7 F which is a few degrees lower than the average for the heating season thus showing operation of the unit on a cold day. It will be noted that the power consumption changes occur in close relationship to the rise and

[1] A Field Study of the Heat Requirements of a College Building, by F. E. Giesecke and W. H. Badgett, A.S.H.V.E. Journal Section, *Heating, Piping and Air Conditioning*, June, 1936.

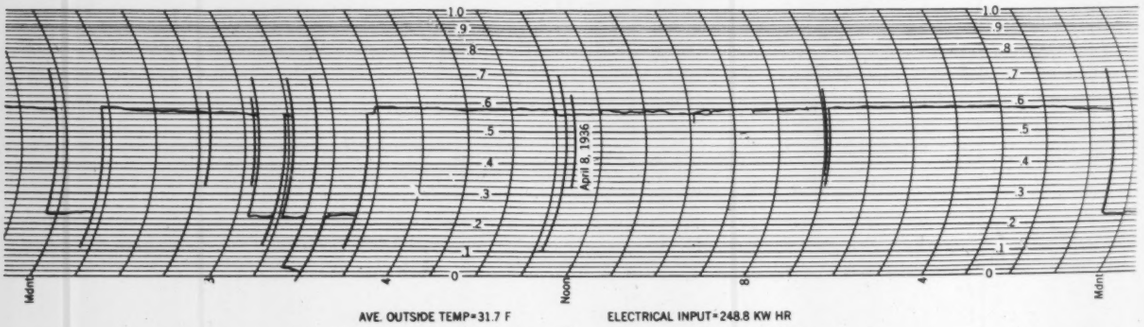


Fig. 10—Chart record of electric input to unit, April 8, 1936

Table 3—Summary of Tabulated Test Results

Heat loss of building, Btu per hour = 77,368
Heat loss of building, Btu per degree temperature difference inside to outside = 1030
Duration of test = 25 days
Average inside temperature = 73 F
Average outside temperature = 47.2 F
Total degree temperature difference day = 645.2
Estimated heat requirement = 645.2 × 1030 × 24 = 15,980,000 Btu
Total electric input = 3877 kwhr or 3,877,000 whr.
Heat input = 3,877,000 × 3.415 = 13,220,000 Btu
Excess estimated heat requirement over actual heat supplied
15,980,000 — 13,220,000 = 2,760,000 Btu
2,760,000 ÷ 13,220,000 = 20.9 per cent estimated higher than actual requirement
Kilowatthour per degree temperature difference day = 3,887,000 ÷ 645.2 = 6.02
Average temperature October 1 to May 1 for Utica, N. Y. = 35 F
Estimated kilowatthour consumption per heating season:
(70 — 35) × 210 = 7350 degree temperature difference days
7350 × 6.02 = 44,250 kwhr Total

Table 4—Daily Summary Load Steps from Graphic Electric Input Chart

Date	Heating Element—Time in Minutes				Total Minutes
	Off	Low 4.5 Kwhr	Medium 7.5 Kwhr	High 12.0 Kwhr	
April					
7	10	547	158	725	1440
8	28	184	3	1225	1440
9		630		810	1440
10		725		715	1440
11	2	930	27	481	1440
12		1036	76	328	1440
13		1164	5	271	1440
14		1106	6	328	1440
15	3	1322		115	1440
16	2	735	23	680	1440
17		596	9	835	1440
18	3	593	9	835	1440
19		873	18	549	1440
20		1106	10	324	1440
21	3	893	14	530	1440
22		467	82	891	1440
23		979		461	1440
24		847		593	1440
25		1038		402	1440
26		1232	3	205	1440
27		1133	25	282	1440
28	2	1438			1440
29	595	845			1440
30	1322	118			1440
May					
1	1321	35	80	4	1440
Totals	3291	20572	548	11589	36000

fall of the outside temperature as shown for the corresponding day in Fig. 11.

A mild day operation of the unit is exemplified in Figs. 12 and 13 where the average outside temperature

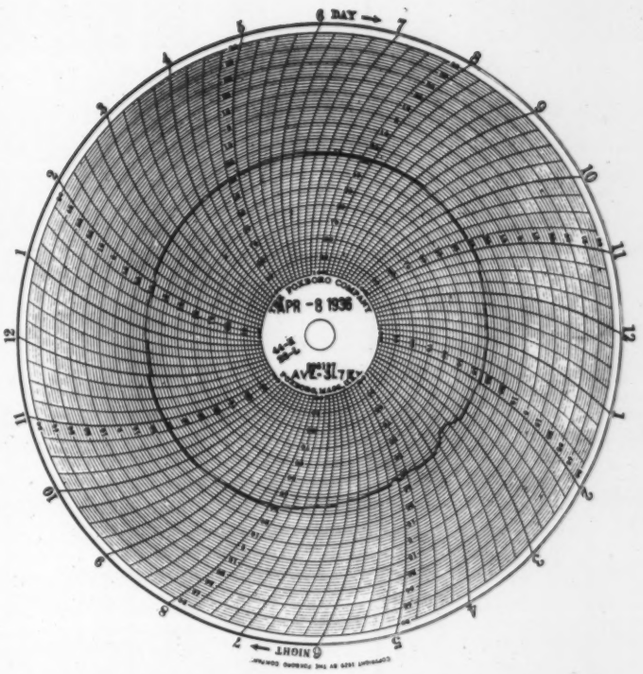


Fig. 11—Daily chart of outside temperatures, April 8, 1936

is 51.5 F and the kilowatt hours per degree temperature difference day is 5.78. Little variation in the power requirements for this particular day will be observed with operation of the limit control switch maintaining sufficient heat energy in the inner electric elements to balance the heat losses of the residence.

Summary

It is recognized that the test results obtained over a limited period of 25 days on a unit of this design are not entirely conclusive nor are they in any way indicative of the thermal efficiency of the boiler. However, the fact that this electric boiler was installed in an actual house having few refinements of modern construction, and operated so as to maintain comfortable temperature conditions with a record of power consumption and related test data from which reasonable calculations and conclusions were obtained, is some indication of its practicability.

As a matter of fact, there were rather conclusive evidences observed which indicated that the actual power

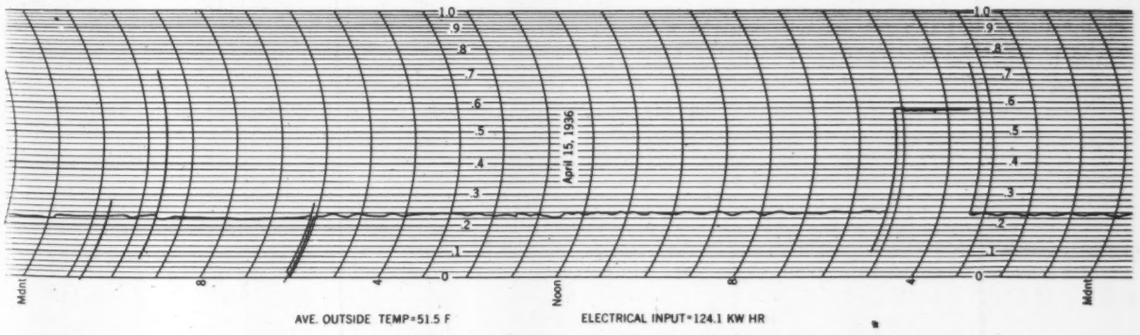


Fig. 12—Chart record of electric input to unit, April 15, 1936

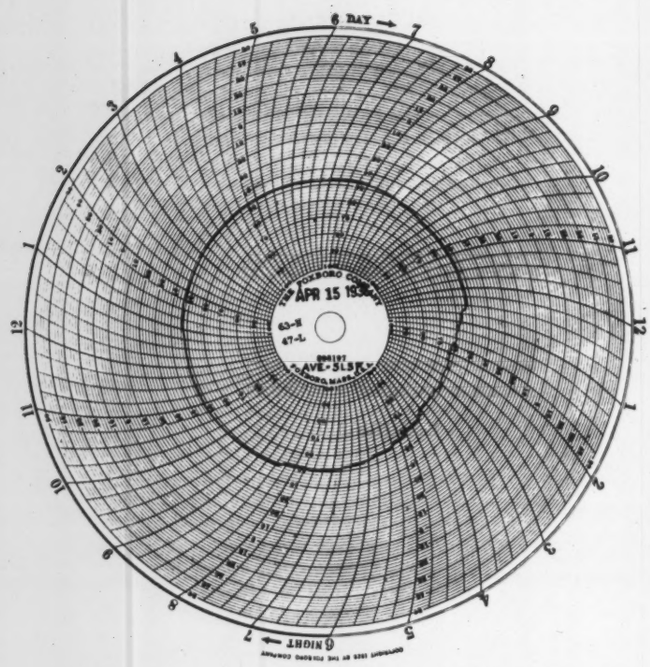


Fig. 13—Daily chart of outside temperatures, April 15, 1936

consumption was probably higher than would have been normally required if the occupants of the residence had been informed of factors which influenced the final results. For instance, if lower night temperatures had been maintained during a time coincident with open windows used for sleeping, lower power consumptions could have been obtained. Also the fact that it was impractical to attempt regulation of the open windows on the second floor, of course, had its contributing influences on the results. All of these factors had a tendency to increase the electrical input which was estimated from the test results to be 44,250 kwhr for a heating season in Utica, N. Y., and for a residence having a calculated heat loss of 77,368 Btu per hour. If a common type of insulation was applied to the exterior walls of the residence, a noticeable reduction in the electrical input could also be anticipated.

In an annual report recently published by the Department of Lighting at Seattle, Wash., it was indicated that experiments over a period of 20 years have shown that electrical heating for the home will compete with other forms of heat if the rate is 6 mills per kilowatthour or less. Tests conducted on the electric boiler in the Utica residence partially confirm the Seattle experiments, but it should be noted in establishing cost comparisons for any other locality, from the results reported in this paper, that the present Seattle rate for the home is about 7.5 mills per kilowatthour, and also that this territory has a smaller number of degree temperature days than Utica. Any future probable reduced electric heating rate for a locality similar to Utica is dependent upon several indeterminate factors of economics and load demands, but if a rate of 6 mills per kilowatthour was applied to the results obtained in this test, the estimated yearly heating cost would be 44,250 × $.006 = $265.50.

It is not the intention of this paper to show any immediate prospect of other means of heating being replaced by electric power, except in districts where the latter is cheaper and the costs of the available fuels are comparatively high. It should be stated, however, that the trend of electric cost is downward.

From observations made during this test it was evident that improved design refinements could be included in boiler units subsequently built. For example, the addition of a booster electric element could be coordinated to function in the control circuit and even out the wide fluctuations in power consumption. A vacuum check valve located near the boiler in the small copper connecting tubing to the pump would tend to minimize leaks, and maintain a higher uniform vacuum. If the metal shells enclosing the heating section were nickel plated, radiation losses would be reduced.

Although this unit was designed and tested using a 220 volt, 3 phase electric power supply, it should be noted that the heating elements may be designed for a 220 volt, single phase circuit.

Observations made in connection with this test suggest the following additional features of design that should be noted if additional experimental units are installed:

1. Due to the small heat storage capacity of the five heating sections, localized heating is possible. (The heating sections have a total water capacity of 12 gal, whereas the capacity of the entire hot water heating system for this test was approximately 125 gal.)
2. With the electric heating elements not in direct contact with the water, no indication of corrosion or electrolysis was apparent.
3. Possibility of operating unit fully automatic, and adaptability for steam generation with various types of air conditioning arrangements.
4. Light weight of unit and adaptability for expansion of capacity.
5. Maintenance reduced to a minimum and no fuel storage requirements.
6. The appeal of clean operation and absence of customary chimney for heating unit.

Acknowledgment

Acknowledgment is due Joseph H. Knapp, designer of the electrical boiler, for his cooperation in the correlation of test and design information for this unit. Also the helpful assistance of Messrs. A. DeRosa, T. C. Redmond, H. Partlow, A. T. Gruenberg, and the following Utica Gas & Electric Company's engineers, George Freer, Jr., Hugh Laurie, H. Underwood, W. A. Mahar, and Clifford Batly, who tabulated the electric input data from the graphic chart was greatly appreciated.

Statistics on Air Conditioning Orders

Statistics for the month of June on the value of orders booked for air conditioning systems and equipment have been released by the Bureau of Census, Department of Commerce, Washington, D. C. A survey of the figures included in this report indicates that from 98 manufacturers in this particular field, that during the first six months of this year from January to June, a total of $20,416,446 have been booked and recorded from information supplied by the various individual manufacturers. The total value of orders reported by these same manufacturers during June, 1936, amounted to $4,336,636 as compared with $4,412,681 for May, 1936.

Buffalo Adopts Comfort Air Conditioning Standards

VARIOUS chapters of the A.S.H.V.E., notably in Chicago, Los Angeles and Buffalo, have formulated comfort air conditioning application standards, covering minimum conditions of design and installation.

The Western New York A.S.H.V.E. Chapter Code which follows is a typical illustration of local application standards. In the preparation of this particular material, the following Committee compiled the Code: L. A. Harding, *Chairman*, and Messrs. H. V. Alexander, M. C. Beman, A. A. Criqui, P. D. Freudenberger, C. J. Hamlin, V. P. John, Fred Kaiser, J. J. Landers, Theo. Messenger, Clarence Meyer, R. H. Mollenberg, J. J. Scanlon, Harry Schaefer, Herman Seelbach, N. E. Sheldon, John Smith, S. W. Strouse, and W. E. Voisinet.

Comfort Air Conditioning Standards

Foreword

The sponsors of this Code have recognized the desirability of adopting various minimum requirements to be applied in the design and installation of air conditioning systems.

The object is primarily for the purpose of furnishing a guide to both the purchaser and vendor of equipment employed for the above mentioned purpose in keeping with acceptable practice in this particular field of engineering.

The sponsors believe the adoption of the minimum requirements herein enumerated will serve, in a great measure, to protect the public against inadequate and improperly designed systems.

1. Scope

These standards are intended to set forth minimum requirements for comfort air conditioning and are not to be construed as applicable to commercial air conditioning, limiting good practice or preventing progress or invention in the art of air conditioning.

The standards are intended to be applied only to systems provided with mechanical circulation of the air.

2. Definitions

Air conditioning is the simultaneous automatic control of the (1) temperature; (2) humidity; (3) cleanliness; (4) distribution and (5) quality of air within an enclosed area.

The following definitions were prepared by a joint committee[1] of the A.S.H.V.E. and *A.S.R.E.* It is understood, wherever the terms given in bold face type are employed, they shall be construed as stated.

a. AN AIR CONDITIONING SYSTEM provides ventilation, air circulation, air cleaning and equipment for maintaining temperature and humidity within prescribed limits.

b. COMFORT AIR CONDITIONING provides ventilation, air circulation, air cleaning and maintains temperature and humidity for the comfort of people.

c. COMMERCIAL AIR CONDITIONING provides ventilation, air circulation, air cleaning and maintains temperature and humidity for the benefit of products or industrial processes.

d. A UNIT is a factory-made, encased assembly of the functional elements, indicated by its name, such as air conditioning unit, room cooling unit, humidifying unit, etc.

e. AN AIR CONDITIONING UNIT is a specific air treating combination consisting of means for ventilation, air circulation, air cleaning and heat transfer with control means for maintaining temperature and humidity within prescribed limits.

f. A COOLING AIR CONDITIONING UNIT is a specific air treating combination consisting of means for ventilation, air circulation, air cleaning and heat transfer with control means for cooling and maintaining humidity within prescribed limits.

g. A HEATING AIR CONDITIONING UNIT is a specific air treating combination consisting of means for ventilation, air circulation, air cleaning and heat transfer with control means for heating and maintaining humidity within prescribed limits.

h. A COOLING UNIT is a specific air treating combination consisting of means for air circulation and cooling within prescribed temperature limits.

i. A HEATING UNIT is a specific air treating combination consisting of means for air circulation and heating within prescribed temperature limits.

j. A HUMIDIFYING UNIT adds water vapor to and circulates air in a space to be humidified.

k. A DEHUMIDIFYING UNIT removes water from and circulates air in a space to be dehumidified.

l. A SELF-CONTAINED AIR CONDITIONING OR COOLING UNIT is one in which a condensing unit is combined in the same cabinet with the other functional elements.

m. A FREE DELIVERY TYPE UNIT takes in air and discharges it directly to the space to be treated without external elements which impose air resistance.

n. A PRESSURE TYPE UNIT is for use with one or more external elements which impose air resistance.

o. AN AIR HEAT INTERCHANGER effects a transfer of heat between air and a heating or cooling medium.

3. Design Temperature Conditions

Temperature: All temperatures stated in this Code are Fahrenheit scale.

a. *Winter Season:*

Outside air 20 F above the lowest official recorded dry-bulb temperature.

For Buffalo = 0 F.

Inside air 70 F dry-bulb 3 ft above floor line with humidifying apparatus designed to provide a minimum of 35 per cent relative humidity.

(A room relative humidity of 35 per cent with 70 F dry-bulb will cause moisture precipitation on single windows when outside air is below 30 F dry-bulb.)

b. *Summer Season:*

Outside air 95 F dry-bulb with 75 F wet-bulb (approximately 39 per cent relative humidity).

Inside air 80 F dry-bulb 3 ft above floor line with 67 F wet-bulb (approximately 50 per cent relative humidity).

Condensing water temperature shall, unless otherwise stated, be considered as follows:

City water (Buffalo)	75 F
Cooling tower water	80 F
Artesian well water	55 F

4. Design Room Air Inlet Temperature and Air Distribution

Summer Season:

The design room air inlet temperature shall not be less than 60 F for cooling and dehumidification when duct outlets are

[1]Proposed Standard Method of Rating and Testing Air Conditioning Equipment. Code prepared by Joint Committee of *American Society of Refrigerating Engineers*, American Society of Heating and Ventilating Engineers, *Refrigerating Machinery Association, National Electric Manufacturers Association* and *Air Conditioning Manufacturers Association.*

provided with diffusion type grilles and not less than 65 F with cross bar type grilles.

The velocity of air through the net face area of cross bar type grilles shall not exceed 350 fpm.

Velocity through diffusion type outlets and grilles shall not exceed the velocities as recommended by the manufacturers of such outlets and grilles it is proposed to employ for the type of installation involved.

The air distribution in the conditioned room shall be such that the air velocity through the occupied zone (3 ft above floor line) shall not exceed 50 fpm and the air temperature maintained within this zone shall not vary more than 3 F measured at the same level.

5. Design Heat Transmission Coefficients for Building Construction

The coefficients to be employed are those given in the current edition of the THE A.S.H.V.E. GUIDE.

The design temperature difference to be employed for heating load (winter operation) for outside walls and roof construction shall be the difference between the design inside and outside air temperatures or 70 F plus 1 per cent for each foot of height above 3 ft up to 20 ft above the floor level and the temperature below zero used for outside air conditions. The design temperature difference for cooling load (summer operation) shall be 15 F.

The design temperature difference to be employed for partitions between a heated and unheated space shall not be less than 30 F and for partitions between a cool and uncooled space not less than 15 F.

6. Design Sun Effect for Vertical Windows

The assumed amount of solar heat entering a room from the sun's rays impinging upon unshaded vertical windows and skylights glazed with ordinary glass shall not be less than the following amounts for cooling load design purposes.

Single sash, east and west walls..... 150 Btu per square foot per hour
Single sash, south wall ..... 65 Btu per square foot per hour
Skylights (Horizontal) ..... 210 Btu per square foot per hour

The design allowance for shading from sunshine shall be made only when the plans and specifications specifically show such allowance and when they give assurance that the owner is cognizant of the reduction in capacity on this account. See current edition THE A.S.H.V.E. GUIDE.

If double sash windows are employed, the above amounts may be reduced by 40 per cent.

7. Design Sun Effect for Roofs

The assumed design minimum amount of solar heat entering a room through an unshaded roof for cooling load shall be estimated by adding 40 F to the outside design air temperature and calculating the heat transmitted in the manner indicated under the heading Design Transmission Coefficients for Building Construction.

8. Design Sun Effect for Vertical Walls

The assumed design minimum amount of solar heat entering a room through unshaded vertical walls for cooling load shall be estimated in the manner as indicated under the preceding heading. For east and west walls add 15 F to the outside air design temperature and 5 F for south walls.

Note: No account of "Sun Effect" shall be taken in estimating design heating loads.

9. Body Heat and Moisture Loss

The design allowance for body heat and moisture loss for cooling loads shall not be less than the following amounts for 80 F dry-bulb room temperature.

Room Air 80 F dry-bulb	Per Person Seated at Rest	Per Person Light Work or Dancing
Sensible heat Btu per hour	238	240
Latent heat Btu per hour	166[a]	424
Moisture loss, grains per hour[b]	1100[a]	2800

[a]For slight physical exertion (for example, typists) increase these amounts by 50 per cent.
[b]1 pound = 7000 grains.

10. Design Infiltration and Outward Leakage of Air

The minimum assumed design amount of outside air entering a room by infiltration for winter heating design loads shall not be less than the amounts estimated by employing the following tabular data:

Winter Operation

Kind of Room or Building	Assumed No. of Air Changes Taking Place Per Hour
Offices and/or Bedrooms, 1 side exposed	1
Offices and/or Bedroms, 2 sides exposed	1½
Offices and/or Bedrooms, 3 sides exposed	2
Offices and/or Bedrooms, 4 sides exposed	2
Rooms with no windows or outside doors	¾
Entrance Halls	2½
Reception Halls	2
Living Rooms	1½
Dining Rooms	1½
Bath Rooms	2
Drug Stores, Cigar Stores, Restaurants, Cafeterias	2½
Dry Goods, Clothing Stores and General Merchandise Establishments	1
Churches, Theaters, Clubs and Public Assembly Halls	1½

The minimum design amount of outside air entering a room by infiltration for summer cooling loads shall not be less than 75 per cent of the amounts estimated by employing the preceding tabular data.

11. Design Ventilation Air

Specifications or proposals shall include a schedule of the number of persons assumed for the occupancy of each room.

Not less than 10 cfm of outside air per occupant shall be assumed to be drawn into the system for rooms in which the contamination of the air results entirely from the respiratory processes of the occupants.

For dining rooms, restaurants, cafeterias and smoking rooms not less than 20 cfm of outside air per assumed occupant.

12. Design Minimum Quantity of Air to be Circulated

The minimum design amount of air to be circulated through a room shall not be less than 30 cfm per assumed occupant.

13. Design Load Calculations

The following items shall be included in all estimates for air conditioning loads:

Winter Operation (Heat to be supplied in space warmed).

a. Heat transmission of walls, doors, windows, ceilings, floors and partitions.

b. Heating of outside air entering room by infiltration, introduced by positive ventilation or independent air exhaust systems.

Note: Employ either the assumed infiltration, the air removed by exhaust system, or introduced for positive ventilation, whichever is the greater, and not the sum.

No allowance shall be made for heat emitting sources within the room unless specifically mentioned in the proposal or specifications.

Summer Operation (Heat to be extracted).

Sensible Heat

a. Heat transmission of walls, ceilings, floors, partitions, windows, etc.

b. Solar heat.

c. Heat from people.

d. Heat introduced by artificial illumination, electrical appliances, gas appliances, resistance to air flow through apparatus and duct system and any other heat emitting source located within the conditioned room and not otherwise removed. Heat emitting appliances located under an exhaust hood connected with a fan exhaust system will be assumed to add a minimum of 50 per cent of the total heat emitted by such appliances to the room sensible heat load.

e. Heat introduced by outside air entering the room from infiltration, positive ventilation and due to independent air exhaust systems. (See note under Winter Operation, par. 2.)

Vapor Condensation (latent heat)

f. Moisture from persons or any other vapor emitting source

within the room not removed by an independent exhaust system and including the portion of vapor to be condensed from outside air entering by infiltration, ventilation and due to exhaust system. (See note under Winter Operation, par. 2.)

14. Design Air Duct Capacity

Provision shall be made in all installations for the recirculation of 100 per cent of the circulated air.

Note: This provision is made for the purpose of economical operation prior to occupancy.

Provision shall be made in all installations for the circulation of 100 per cent outside air.

15. Minimum Sheet Metal Gages

The following gages for panels shall be employed for all rectangular or square galvanized sheet metal constructed mains, branches and risers (except as otherwise noted) field fabricated casings or housings for heating or cooling coils, air filters, outside air intakes and connections between air washers, heating and cooling coils, fans and air filters.

This provision does not apply to factory assembled units.

If panels are not cross-broken, two gage heavier material is to be employed.

Concealed risers, single or double wall type, for residences run in partitions or outside walls may be constructed of bright tinned sheets of thickness of not less than No. 34 U. S. gage.

Width Duct In.	U. S. Stand. Gage	Wt Galv'd Sheet Lb Sq Ft
Up to 12	28	0.906
13 to 30	26	1.156
31 to 48	24	1.406
49 to 60	22	1.406
61 to 90	20	1.656

If the duct has width or height of more than 24 in., there shall be transverse exterior braces for such surfaces not more than 48 in. on centers. Where *S* cleats and drive cleats are used to connect ducts, formed angle cleats may be used in lieu of the stiffener angles. The same gages as specified above shall apply, for circular ducts of diameter corresponding to the given widths.

Cooling coils to be provided with a water tight drip pan and drain connection.

16. Air Filters

Air filters shall be of sufficient capacity to handle all of the air circulated by the apparatus and to be selected and installed in accordance with the recommendations of the manufacturer.

17. Controls

Specifications and proposals shall clearly describe the functions to be performed by the various proposed automatic control devices.

18. Insulation

Air conditioning installations in which refrigeration is employed shall have all chilled surfaces adequately insulated to prevent condensate forming on the outside surface of the insulation.

19. Apparatus Rating

Fans, air heating and cooling coils shall be rated in accordance with the provisions of the A.S.H.V.E. Standard Test Codes. Motors to be rated in accordance with the provisions of the *A.I.E.E.* standard test code. Vapor compressors and vapor condensers to be rated in accordance with the *A.S.R.E.* Standards.

20. Electrical Wiring for Motors

Electrical wiring for motors shall comply with the Underwriters' rules and regulations.

21. Piping and Plumbing

The materials to be employed for the various classes of piping required shall be fully described by the specifications and proposal. All pipe and fittings conveying water to be galvanized wrought iron or steel, copper or brass. All pipe and fittings employed to be of such wall thickness as will safely carry the internal pressure imposed under the normal operation of the system. Plumbing to comply with local ordinances.

22. Refrigerating Apparatus

a. A liquid receiver of sufficient capacity to store the entire operating charge of refrigerant shall be provided for all refrigerating machines, except those types employing water vapor for the refrigerant. The condenser may also be employed to serve this purpose when so described in the specifications and proposal.

b. All safety features of the installation shall comply with state and municipal laws or ordinances having jurisdiction.

c. Apparatus such as evaporators, condensing units, expansion valves, etc. shall be installed with sufficient line valves and with proper fittings to permit efficient servicing or quick replacement of operating parts without exposing the interior of the refrigerant-containing parts to air and moisture where such exposure would affect the system adversely.

23. Minimum Capacity of Installed Equipment

The installed air conditioning equipment and apparatus involved shall be provided with a rated capacity of not less than the estimated design loads as indicated under heading No. 13 Design Load Calculations to which the following percentages shall be added to the sensible heat load for cooling equipment (summer operation) to allow for the starting up load.

Design sensible heat cooling load—Tons refrigeration[c]	Percentage to be added	Design sensible heat cooling load—Tons refrigeration[c]	Percentage to be added
0-1	25	10-14	12
2-4	22	14-16	10
4-6	18	16-20	8
6-8	16	20-25	6
8-10	15	25 and above	5

[c]Ton Refrigeration = 12,000 Btu per hour.

If heating boilers are included the installed maximum rated boiler output capacity shall not be less than the output as determined by the A.S.H.V.E. Code of Minimum Requirements.

24. Noise Control

Until such time as the A.S.H.V.E. adopts standards for noise control and its measurement the maximum velocities through outlet grilles as recommended by the manufacturer of such grilles for the type of installation involved shall not be exceeded. The fan and motor shall rest upon a sound deadening material.

25. Guarantees

a. Replacement guarantees covering individual equipment shall be limited to the recognized practice of the manufacturers' association of such equipment.

b. Guarantees of performance, when required, shall be limited to stated capacities that are to be fully described in either the specifications or proposal or both.

c. All operating temperatures and pressure conditions under which the guaranteed capacities are made shall be fully described.

d. If a field performance test is required, the specifications shall fully describe, in detail, the acceptable methods and apparatus to be employed in making the necessary measurements for the following items that may be applicable; temperatures, pressures, air quantity, steam quantity, water quantity, resistances and power requirement.

e. The purchaser to reproduce the conditions under which the cooling load was originally estimated within 10 per cent of both the sensible and latent heat loads at the time of test.

f. The following procedure for determining refrigeration tonnage in field tests of air conditioning equipment to be considered acceptable:

$$H = 1.05\ (H_e - H_m).$$

Where

H_e = heat removed by condensing water, Btu per hour.

H_m = heat equivalent of power input to compressor, Btu per hour.

H = heat absorbed by evaporator, Btu per hour.

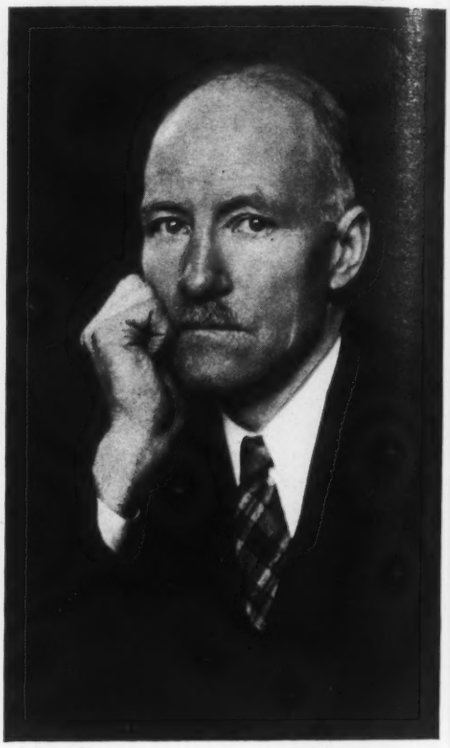
1.05 = allowance factor to cover estimated heat removed from compressor, condenser and piping by radiation and convection.

$$T = H/12{,}000.$$

Where

T = tonnage, 1 Ton = 12,000 Btu per hour.

A Bigger Program to Meet Research Needs



W. A. Danielson
Chairman, Committee on Research

ENGINEERS engaged in heating, ventilating and air conditioning find that the lack of fundamental data is a severe handicap to the development and growth of their profession and they also recognize the fact that research by an unbiased technical organization is the only successful way of obtaining essential, authoritative information.

As research has been a major activity of the A.S.H.V.E. for 15 years the scope of its work can be visualized by reference to the TRANSACTIONS, where detailed reports on the work done in the Pittsburgh Laboratory and in cooperating universities and colleges show definitely that something worth while has been created for the benefit of the profession and industry.

The research sponsored by the Society has involved the expenditure of over a half-million dollars and the facts that have been established are the foundation of engineering practice in the field today. Because the results of research are often slow in finding their way into practice, many of those making commercial and practical use of the Society's research findings are not even cognizant of their source.

Typical of the work done by the Society in various phases of heating, ventilating and air conditioning are the following:

1. The Society's studies on air conditions and their relation to the comfort of man form the basis upon which rests the present acceptance and practice of air conditioning. The establishment of the comfort zone in terms of effective temperature through research at the Society's Laboratory is now generally accepted as basic; the wide application of space cooling makes it imperative that further work on comfort studies be done in this field.
2. Standardization of pipe sizes for steam and hot water heating systems.
3. Investigations of heat transfer through building materials, contributing to standardization of heat transfer coefficients from a condition of many variable sources of data to a condition where a commonly accepted set of values is now universally used. Transmission coefficients for a great variety of building materials have been established on the basis of studies at various laboratories, including that of the Society, which are used every day.
4. Surface coefficients in relation to wind velocity have been established on a sound basis. The development of the Nicholls heat flow meter has assisted immeasurably in the study of actual heat losses from buildings.
5. Many codes of performance have been standardized, including those of heating boilers, blowers, unit heaters, air cleaning devices, radiation, and their development has involved some research.

There is much more that must be accomplished. The demand for facts continues and the Committee on Research has organized Technical Advisory groups to undertake investigations on a wider scale than has been attempted previously. These projects are being assigned to the Pittsburgh Laboratory and to cooperating institutions as rapidly as funds become available. Further financial support must be forthcoming for the successful study of the following projects which are of the greatest importance to the profession and industry:

1. Air conditions in relation to comfort.
2. Air conditioning in the treatment of diseases.
3. Atmospheric impurities and resulting safety and health requirements.
4. Comfort requirements of summer cooling.
5. Corrosion in heating and air conditioning systems.

C. E. Lewis
Vice-Chairman, Committee on Research

G. L. Larson
President, A.S.H.V.E.

6. Air distribution within an enclosure.
7. Frictional resistance to air flow in small ducts and fittings.
8. Heat transfer of finned tubes with forced air circulation.
9. Heating and cooling requirements of buildings.
10. Refrigeration in relation to air treatment.
11. Sound and relationship to heating and ventilation.
12. Direct and indirect radiation performance with gravity air flow.

There are many more investigations needed, for example:

1. Experimentation to determine the proper size of steam pressure reducing valves for different pressure drops.
2. The practical limitations of air velocity and difference in temperature between room temperature and air delivery temperature in the use of unit ventilators in heating and ventilating schoolrooms.

F. C. Houghten
Director, A.S.H.V.E.
Research Laboratory

3. The proper method and place of introduction of cool air introduced in any room for room cooling with a study of the safe limits of difference in temperatures between the room and incoming air.
4. A standardization of the calculated drop in temperature through a radiator in a forced circulation hot water heating job.
5. A study of the simplest and lowest cost low pressure steam and hot water heating jobs that can be safely installed in low cost homes.
6. Forced hot water circulation systems with small pipes need further study.
7. Studies to determine the effectiveness of commercial insulations against the flow of heat either into or out of buildings through walls, ceilings and roofs.
8. Comparisons of pressure losses in radius and square bends in duct work at different air velocities.

The Society's research organization is ready to proceed with these and many other projects.

To do some of the work in 1936-37, a goal of $100,000 has been set by the Research Finance Committee and the feeling is that the profession and industry will respond wholeheartedly because it has been demonstrated that cooperative research finds the facts and is a worthwhile investment.

Third World Power Conference

The Third World Power Conference will be held in Washington, D. C., Sept. 7-12. The program is divided into two parts, (1) general sessions in Washington to discuss engineering topics of importance, and (2) study tours to industrial centers.

An imposing program has been arranged and the American National Committee has completed arrangements for handling a large attendance at the various sessions. The conference is sponsored and financed jointly by the U. S. Government and the electrical industry of the country.

American Engineering Council has accepted the invitation of the officials of the Third World Power Conference to sponsor that part of its exhibition designed to give delegates from other countries a comprehensive understanding of the number, sizes and purposes of the national, state and local engineering organizations in the United States and the objectives and facilities of the functional organizations or instrumentalities for united action supported by engineering organizations.

With the assistance of the Founder Societies and the other functional organizations, the American Engineering Council is preparing a limited number of souvenir brochures to be presented to the delegates from other countries to the Third World Power Conference. The brochure will memorialize the Engineers' Exhibition, provide a complete list of the engineering organizations of the United States, and indicate the membership of each organization including citizens and residents of foreign countries. Appropriate statements in the brochure will relate the several branches of engineering to the power industry and to the utilization and conservation of power resources.

A personal greeting will be extended to all delegates by an Engineers' World Power Conference Committee and members of the staff of American Engineering Council will be in attendance to welcome engineers from other countries and to help them make desirable contacts and otherwise enjoy their visit to the United States. All engineers, engineering organizations and their instrumentalities are invited to attend the Third World Power Conference and to cooperate in an intensive effort to have our guests from other countries carry a better understanding and appreciation of engineers, engineering organizations and their allied activities home to their friends and associates.

For the A. S. H. V. E. Pres. G. L. Larson has appointed two official delegates, First Vice-Pres. D. S. Boyden, Boston, and Lt. Col. W. A. Danielson, Washington, D. C., Chairman of the Society's Committee on Research.

Study Courses in Heating, Ventilating and Air Conditioning

DUE to the many requests for information relative to instructional courses offered in heating, ventilating and air conditioning, inquiry was made to the registrars of over 100 universities, colleges, and technical schools requesting an outline of courses offered in these subjects for the years 1936-37. From the data submitted by the various institutions the following information was tabulated for quick reference. As additional information is obtained supplementary tables will be published.

It should be noted that several of these schools give courses in heating, ventilating and air conditioning in connection with a full undergraduate program in mechanical engineering, and in some instances graduate school instruction is offered for those desiring to specialize in this field of engineering. Information is also given for those individuals desiring evening instruction or correspondence courses.

Universities, Colleges and Technical Schools Offering Courses in Heating, Ventilating and Air Conditioning, 1936-37

NAME	ADDRESS	INSTRUCTORS	Registration Date	SESSION	FEE	SUBJECTS	REMARKS
EAST							
Carnegie Institute of Technology	Pittsburgh, Pa.	C. M. Humphreys	Sept. 25 Oct. 5	Day Evening	$300 per year $35-$40 per yr.	Basic Thermodynamics, Plumbing, Heating, Ventilating Basic Thermodynamics, Plumbing, Heating, Ventilating, Air Conditioning	4-year Mech. Engr. Option in Plumbing, Heating, Ventilating, beginning Soph. yr. Courses leading to Certificate and Degrees
Clemson Agricultural College	Clemson, S. C.	D. H. Shenk	Sept. 9	Day	Regular Tuition	Basic Thermodynamics, Heating and Ventilating	Option in Mech. Engr. Courses
College City of New York	New York, N. Y.	F. W. Hanburger	Sept. 21	Evening	$27.50	Heating and Ventilating	Presented in connection with Architecture and Building Construction Courses
Columbia Technical Institute	Washington, D. C.	Malcolm Hickox S. L. Richmond	Sept. 15	Evening and Correspondence	Tuition fee	Heating, Ventilating and Air Conditioning	Option in Mech. Engr. and one-year Certificate Course
Columbia University	New York, N. Y.	R. W. Waterfill C. A. Bulkeley	Sept. 21	Evening	$30 per course	Elementary and Advanced Courses in Air Conditioning	Presented in School of Architecture
Connecticut State College	Storrs, Conn.	W. L. Edel	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heat Engineering	Courses in Mech. Engr.
Cornell University	Ithaca, N. Y.	F. O. Ellenwood C. O. Mackey	Sept. 28	Day	Regular Tuition	Basic Thermodynamics, Air Conditioning, Refrigeration	Graduate Courses and Required or Optional in Mech. Engr.
Drexel Institute of Technology	Philadelphia, Pa.	E. J. Berllet J. H. Rushton	Sept. 8	Evening	Regular Tuition	Basic Thermodynamics, Air Conditioning	Diploma Course in Mech. Engr.
Georgia School of Technology	Atlanta, Ga.	R. S. King	Sept. 15	Day and Evening	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Refrigeration	Presented in Mech. Engr. Course
Harvard University	Cambridge, Mass.	C. H. Berry F. R. Ellis C. P. Yaglou	Sept. 28	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Graduate Courses and Required or Elective in Mech. Engr.
Herkimer Institute	New York, N. Y.	J. L. Blackshaw		Day and Evening	Tuition fee	Air Conditioning and Refrigeration	
International Correspondence Schools	Scranton, Pa.	B. B. Mahon		Correspondence	Course fee	Air Conditioning	
Lehigh University	Bethlehem, Pa.	E. H. Jennings	Sept. 21	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required and Elective in Mech. Engr.
Massachusetts Institute of Technology	Cambridge, Mass.	James Holt	Sept. 21	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, and Air Conditioning	Graduate Courses and Required or Elective in Mech. Engr.
Massachusetts University Extension Division	Boston, Mass.	J. A. Moyer		Correspondence	Course fees	Air Conditioning	
Newark College of Engineering	Newark, N. J.	F. D. Carvin	Sept. 14	Day and Evening	$30	Heating and Ventilating	Senior Mech. Engr. Course
New York University	New York, N. Y.	M. C. Giannini	Sept. 8	Day and Evening	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	2-year Certificate Program and Graduate Courses in Mech. Engr.
Pennsylvania State College	State College, Pa.	H. A. Everett	Sept. 10	Day	Regular Tuition	Basic Thermodynamics, Heating and Ventilating	Required Course in Mech. Engr.
Polytechnic Institute of Brooklyn	Brooklyn, N. Y.	John James	Sept. 18	Evening	$35 per semester	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Elective Course in Mech. Engr.
Pratt Institute	Brooklyn, N. Y.	J. W. Hunter	Sept. 15	Day and Evening	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required and Elective Mech. Engr. Course
Rensselaer Polytechnic Institute	Troy, N. Y.	E. A. Fessenden	Nov. 1	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Senior Course in Mech. Engr.
Rutgers University	New Brunswick, N. J.		Sept. 15	Correspondence	$25 per course	Heating, Ventilating, Air Conditioning	

NAME	ADDRESS	INSTRUCTORS	Registration Date	SESSION	FEE	SUBJECTS	REMARKS
Stevens Institute of Technology	Hoboken, N. J.	E. H. Fezandie J. I. Yellott	Sept. 22	Day	Regular Tuition	Basic Thermodynamics, Heating, Air Conditioning, Ventilating	Graduate Courses and Required or Elective in Mech. Engr.
University of Delaware	Newark, Del.	R. L. Spencer	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Presented in Mech. Engr. Courses
University of Florida	Gainesville, Fla.	N. C. Ebaugh	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required and Elective Mech. Engr. Course
University of Maryland	College Park, Md.	R. S. Dill	Sept. 17	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Refrigeration	Presented in Mech. Engr. Courses
University of New Hampshire	Durham, N. H.	E. H. Stolworthy	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating	Required Mech. Engr. Course
University of North Carolina	Raleigh, N. C.	L. L. Vaughan F. B. Turner	Sept. 15	Day Correspondence	Regular Tuition $7.50 Course	Basic Thermodynamics, Heating, Air Conditioning, Refrigeration Air Conditioning	Presented in Senior Mech. Engr. Course Extension Division
University of Pennsylvania	Philadelphia, Pa.	W. A. Sloan	Sept. 28	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating	Presented in Mech. Engr. Course
Villanova College	Villanova, Pa.	J. S. Morehouse	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required Senior Course in Mech. Engr.
Virginia Polytechnic Institute	Blacksburg, Va.	J. I. Clower	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Presented in Mech. Engr. Course
Wentworth Institute	Boston, Mass.	M. G. Noles	Sept. 21	Day and Evening	Regular Tuition	Air Conditioning	Certificate Course
West Virginia University	Morgantown, W. Va.	J. B. Grumbein	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating and Ventilating	Presented in Mech. Engr. Course
Worcester Polytechnic Institute	Worcester, Mass.	R. P. Kolb	Sept. 28	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating	Presented in Mech. Engr. Course
Yale University	New Haven, Conn.	L. E. Seeley	Sept. 21	Day	Regular Tuition	Basic Thermodynamics, Heating and Air Conditioning	Graduate Courses and Required or Elective Mech. Engr.
CENTRAL							
Arkansas State College	State College, Ark.	N. H. Brown	Sept. 7	Day	Regular Tuition	Refrigeration and Air Conditioning	Course in Engineering
Armour Institute of Technology	Chicago, Ill.	Le Roy Shields H. N. Nachman	Sept. 28	Day and Evening	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required in Mech. Engr. Course
Case School of Applied Science	Cleveland, Ohio	G. L. Tuve C. A. McKeeman	Sept. 21	Day and Evening	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required and Elective in Mech. Engr. Course
Chicago Technical College	Chicago, Ill.	W. T. Hooper Albert Pelletier	Sept. 8	Day, Evening, Correspondence	Course Fees	Air Conditioning	Short Course, four to nine months
David Ranken Jr.	St. Louis, Mo.		Sept. 8	Day and Evening	Course Fees	Air Conditioning	Course, one to three years
Fenn College	Cleveland, Ohio	Vincent Eaton	Sept. 23	Evening	$31 Elementary $18.50 Advanced	Elementary and Advanced Air Conditioning	
Kansas State College	Manhattan, Kan.	A. J. Mack B. B. Brainard	Sept. 14	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required and Elective in Mech. Engr. Course
Lewis Institute	Chicago, Ill.	V. L. Sherman Mr. Bodinus	Sept. 21	Day and Evening	$25 per term	Air Conditioning, Refrigeration	
McKim Technical Institute	Akron, Ohio			Day and Evening	$175.50	Refrigeration and Air Conditioning	Combined Course
Michigan College of Mining and Technology	Houghton, Mich.	A. P. Young	Sept. 24	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating	Elective in Mech. Eng. Course
Mississippi State College	State College, Miss.	R. C. Carpenter	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating	Required in Mech. Engr. Course
Ohio Mechanics Institute	Cincinnati, Ohio	J. T. Faig		Evening		Heating, Ventilating, Air Conditioning	
Ohio State College	Columbus, Ohio	A. I. Brown	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required and Elective in Mech. Engr. Course
Oklahoma Agricultural and Mechanical College	Stillwater, Okla.	V. W. Young		Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Offered in Architectural Dept. and Mech. Engr. Course
Purdue University	Lafayette, Ind.	W. T. Miller	Sept. 12	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Graduate Courses and Required or Elective in Mech. Engr.
Refrigeration & Air Conditioning Institute, Inc.	Chicago, Ill.			Correspondence and Shop	$147	Air Conditioning, Refrigeration, Heating, and Ventilation	Following completion of the home study work, the student is given two weeks of laboratory and shop training at Chicago
St. Louis Technical Institute	St. Louis, Mo.	O. W. Kothe		Correspondence	Course Fees	Heating, Ventilating, Air Conditioning	
University of Akron	Akron, Ohio	F. S. Griffin	Sept. 5	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating	Course in Mech. Engr.
University of Cincinnati	Cincinnati, Ohio	C. A. Joerger	Sept. 21	Evening	$20 per year	Heating and Ventilating	Alternate Course in Air Conditioning given 1937
University of Illinois	Urbana, Ill.	W. H. Severns	Sept. 21	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Graduate Courses and Required or Elective in Mech. Engr.

NAME	ADDRESS	INSTRUCTORS	Registration Date	SESSION	FEE	SUBJECTS	REMARKS
University of Kentucky	Lexington, Ky.	L. S. O'Bannon	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required or Elective in Mech. Engr. Course
University of Louisville	Louisville, Ky.		Sept. 8	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Courses in Mech. Engr.
University of Minnesota	Minneapolis, Minn.	F. B. Rowley	Sept. 21	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Graduate Courses and Required or Elective in Mech. Engr.
University of Missouri	Columbia, Mo.	Mr. Gray	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Air Conditioning	Course in Mech. Engr.
University of Nebraska	Lincoln, Neb.	A. E. Luebs	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Refrigeration, Heating, Ventilation	Elective in Mech. Engr. Course
University of Oklahoma	Norman, Okla.	W. H. Carson E. F. Dawson	Sept. 9	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Graduate Courses and Required or Elective in Mech. Engr.
University of Tennessee	Knoxville, Tenn.	C. E. Ferris	Sept. 17	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required in Mech. Engr. Course
University of Wisconsin	Madison, Wis.	G. L. Larson	Sept. 21	Day and Correspondence	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Graduate Courses and Required or Elective in Mech. Engr.
Washington University	St. Louis, Mo.	E. L. Ohle	Sept. 21	Day	Regular Tuition	Basic Thermodynamics, Heating, Air Conditioning	Elective in Mech. Engr. Course
WEST Agricultural and Mechanical College of Texas	College Station, Texas	C. W. Crawford	Sept. 21	Day	$50 per year	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Elective in Mech. Engr. Course
California Polytechnic School	San Luis Obispo, Calif.	C. E. Knott		Day	$20 per year	Air Conditioning	Two-year Course, Training for Installation and Maintenance
International Engineering Institute	Seattle, Wash.	C. W. Parsons	Oct. 1	Day, Evening, Correspondence	$300 per year $160 (Corres.)	Air Conditioning	
Oregon State College	Corvallis, Oregon	M. C. Phillips W. H. Martin E. C. Willey	Sept. 21	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Graduate Courses and Required or Elective in Mech. Engr.
State College of Washington	Pullman, Wash.	Mr. Thornton	Sept. 21	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Elective in Mech. Engr. Course
University of Arizona	Tucson, Arizona	P. M. Thornburg	Sept. 14	Day	Regular Tuition	Basic Thermodynamics, Air Conditioning	Elective in Mech. Engr. Course
University of California	Berkeley, Calif.	B. M. Woods B. F. Raber L. M. K. Boelter	Sept. 18	Day Evening	Regular Tuition $9 per person ten meetings	Basic Thermodynamics, Heating, Ventilating, Air Conditioning Fundamentals of Air Conditioning	Graduate Courses and Required or Elective in Mech. Engr. Presented by University Extension in San Francisco
University of Colorado	Boulder, Col.	S. L. Simmering	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required in Mech. Engr. Course
University of New Mexico	Albuquerque, N. M.	M. E. Farris	Sept. 14	Day	Regular Tuition	Basic Thermodynamics, Air Conditioning	Optional in Mech. Engr. Course
University of Santa Clara	Santa Clara, Calif.	G. L. Sullivan	Aug. 28	Day	Regular Tuition	Basic Thermodynamics, Heating, Air Conditioning	Presented in Mech. Engr. Course
University of Southern California	Los Angeles, Calif.	T. T. Eyre	Sept. 16	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required in Mech. Engr. Course
University of Texas	Austin, Texas	Mr. Degler	Sept. 18	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Elective in Mech. Engr. Course
University of Utah	Salt Lake City, Utah	E. H. Beckstrand	Sept. 28	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required and Elective in Mech. Engr. Course
University of Washington	Seattle, Wash.	E. O. Eastwood	Sept. 15	Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Required and Elective in Mech. Engr. Course
CANADA Montreal Technical School	Montreal, Quebec		Sept. 8	Day	Regular Tuition	Heating, Ventilating, Air Conditioning	Regular Technical Course
Nova Scotia Technical College	Halifax, Nova Scotia			Day	Regular Tuition	Heating, Ventilating	
University of Manitoba	Winnipeg, Manitoba			Day	Regular Tuition	Heating, Ventilating, Air Conditioning	Course for Architectural Students
University of Toronto	Toronto, Ontario			Day	Regular Tuition	Basic Thermodynamics, Heating, Ventilating, Air Conditioning	Presented in Mech. Engr. Course

Committee on Arrangements for the Society's Annual Meeting

The personnel of the Committee on Arrangements for the Society's 43rd Annual Meeting to be held in St. Louis, January 25-27, 1937, has been announced as follows:

C. R. Davis, *General Chairman.*
L. W. Moon, *Vice-Chairman.*
R. J. Tenkonohy, *Reception.*
P. W. Sodemann, *Transportation.*
D. J. Fagin, *Entertainment.*
G. W. F. Myers, *Banquet.*
J. W. Cooper, *Ladies.*
E. E. Carlson, *Publicity.*
C. E. Hartwein, *Finance.*

At a meeting in St. Louis on July 22, the Committee discussed plans for the entertainment of those who will be guests of the St. Louis Chapter.

The headquarters for the meeting will be the Hotel Statler.

Reorganization of Technologic Branch of Bureau of Mines

The appointment of A. C. Fieldner as chief of the Technologic Branch of the United States Bureau of Mines, Department of the Interior, has been announced by Dr. J. W. Finch, director

A. C. Fieldner

of the Bureau. Mr. Fieldner succeeds O. P. Hood, who recently retired after a long period of service.

Coincident with the appointment of Mr. Fieldner, the Bureau's Technologic Branch has been reorganized, so that the name of the Mechanical Division has been changed to the Coal Division and studies relating to the use of electrical and mechanical equipment in mines have been transferred to the Mining Division.

The Experiment Stations Division has been discontinued, and the coal preparation section of the Experiment Stations Division and the experimental mine section of the office of the chief mining engineer have been transferred to the Coal Division.

A new Non-Metals Division has been created to take over the following technical sections of the discontinued Experiment Stations Division: Fundamentals, Beneficiation, Processing, Utilization and Water.

Hereafter supervising engineers of the various experiment stations will report to the chief engineers of divisions as follows: the supervising engineer of the Pittsburgh Experiment Station will report to the chief engineer of the Coal Division; the supervising engineers of the Minneapolis, Rolla, Salt Lake City, Reno, Boulder City, and Berkeley Experiment Stations will report to the chief engineer of the Metallurgical Division; the supervising engineers of the Tucson Experiment Station will report to the chief engineer of the Mining Division; the supervising engineers of the New Brunswick, Seattle, and Tuscaloosa Stations will report to the chief engineer of the Non-Metals Division; and the supervising engineers of the Bartlesville, Laramie, and Amarillo Stations will report to the chief engineer of the Petroleum and Natural Gas Division. F. L. Hess, principal mineralogist, will report directly to the chief of the Technologic Branch.

The names and titles of the division heads of the Technologic Branch are as follows:

Coal Division.....A. C. Fieldner, chief engineer
Explosives Division.....W. J. Huff, chief chemist
Metallurgical Division.....R. S. Dean, chief engineer
Mining Division.....C. F. Jackson, chief engineer
Non-Metals Division.....O. C. Ralston, chief engineer
Petroleum and Natural Gas Division.....R. A. Cattell, chief engineer

Mr. Fieldner, the new chief of the Technologic Branch, is a native of Ney, Ohio, and a graduate of Ohio Wesleyan University and Ohio State University. Following some years of chemical and fuel engineering work with commercial companies, Mr. Fieldner entered the service of the U. S. Geological Survey in 1907. On the organization of the Bureau of Mines in 1910, he was placed in charge of the fuel chemical laboratory at the Bureau's Pittsburgh, Pa., Experiment Station. He was appointed supervising chemist of the Pittsburgh Station in 1919 and was made chief chemist of the Bureau in 1925. In 1927, he was appointed chief engineer of the Experiment Stations Division.

Mr. Fieldner was in charge of gas mask investigations for the Bureau in the World War period, later being commissioned as major in the Chemical Warfare Service. He developed American methods of testing gas masks, and gas absorbents, and methods of testing and analyzing coal, coke and gas. He had charge of research on ventilation of the Hudson River vehicular tunnel and was co-author of Ventilation of Vehicular Tunnels published in the A.S.H.V.E. JOURNAL during 1926, as well as the author of numerous monographs and scientific articles.

Survey Shows Public Sold on Air Conditioning But Doesn't Know What It Is

What the public thinks about air conditioning is indicated by a questionnaire sent to 10,000 people, the results of which have just been issued by the General Electric Air Conditioning Institute. The questionnaire was sent out anonymously. That the public's knowledge of all the functions of air conditioning is fragmentary; that most home owners have not yet considered it for their present homes; but that they would definitely expect it as a feature of any new home, were revelations which stand out in the survey.

Only nine per cent were able to name six essential functions that identify real air conditioning. That the air is cooled was much the most frequently mentioned fact. For every 100 who specified that function, only 82 knew that it warms air, 68 knew that it dehumidifies, 65 were aware that it humidifies, 46 had the knowledge that it cleans air, and only 40 knew that it circulates air.

In answer to the question, "Have you ever thought of it for your present home," 38% replied "yes," and 51% "no." Two per cent already have it.

Asked, "If you were to buy a new home, would you expect it to be air conditioned," 58% responded that they would, and 31% that they would not.

Furnace Code Committee Meets

A two-day meeting was held at Purdue University, West Lafayette, Ind., July 31 and August 1, by the Code Committee of the *National Warm Air Heating and Air Conditioning Association.*

From left to right, B. F. McLouth, Dail Steel Products Company, Chicago; Prof. A. P. Kratz, University of Illinois; Fred R. Bishop, Detroit, Brundage Company and American Air Filter Company; Jack Stowell, Chicago, Robinson Furnace Co.; W. D. Redrup, Majestic Furnace Co., Huntington; J. E. Maynard, Fox Furnace Co., Elyria, O.; L. N. Smoot, Holland Furnace Co., Holland, Mich.; E. B. Langenberg, Langenberg Heating Co., St. Louis, Mo.; Prof. J. D. Hoffman, Purdue University, head of the practical mechanics department and chairman of the committee

Those in attendance were Prof. J. D. Hoffman, *Chairman;* Prof. A. P. Kratz, B. F. McLouth, F. R. Bishop, Jack Stowell, W. D. Redrup, J. E. Maynard, L. N. Smoot and E. B. Langenberg.

Technical Drawing

Recognizing the phenomenal growth of technical knowledge characteristic of modern civilization and a corresponding development of drawing interpretations, a new book, Technical Drawing, by F. E. Giesecke, Alva Mitchell and H. C. Spencer, has been written to provide a source of information which may be used in instructional work.

Originally the teaching of drawing consisted largely of providing training to develop manual skill, but it is now recognized that this method of approach is no longer sufficient. In this text the authors point out the desirability of teaching the principles of technical drawing and the relation of drawing to the industries with examples intended to develop at least a fair degree of manual skill.

It is not the intention of this book to provide a manual from which drawings may be copied step by step, but rather as a comprehensive treatment of the science of technical drawing arranged logically and containing a group of practical problems which may be used in the development of this subject.

The standardization project of *American Standards Association* for unifying drawing and drafting room practice has been referred to in this text and several of the recommended symbols are included in the appendix.

The introductory chapters in this book include a complete amplification of the instruments, materials, and technique used in the preparation of drawings. Recommendations for the guidance of individuals who are desirous of learning the various lettering styles are outlined in several of the chapters. Other material which is included in this volume is as follows: projections, pictorial drawing, dimensioning, technical sketching, shading, patent office drawing, graphs, as well as architectural, structural and topographic drawing.

This book is cloth bound, containing 564 pages, and may be obtained from the Macmillan Co., 60 Fifth Ave., New York, N. Y., for $3.00.

Attends Inauguration

On August 6, J. H. Walker, chairman of the Society's Guide Publication Committee and superintendent of Central Heating for Detroit Edison Co., attended the inauguration of Dr. Dillman, the new President of the Michigan College of Mining and Technology, as official representative of the A.S.H.V.E.

Returns from Alaskan Trip

Col. W. A. Danielson, Chairman of the Committee on Research, has just returned to the United States from Alaska, where he visited Fairbanks, Seward, Juneau and some of the remote U. S. Army posts. His tour of inspection will continue in various western states.

Death of E. A. Glanz

E. A. Glanz, president of Glanz and Killian Company, Detroit, Mich., died after a brief illness in Grass Hospital on Sunday, July 19. Funeral services were held on Wednesday, July 22, with burial in Forest Lawn Cemetery.

Mr. Glanz was a well-known heating, ventilating and plumbing contractor in Detroit and since 1920 had been president and general manager of his firm. He was born June 1, 1888 in Warsaw, Poland, of German parents and came to the United States in 1906 where he was employed as an apprentice. He was with C. H. Dean Co. twelve years and then started his own business in 1920 in partnership with M. A. Killian and incorporated the business in 1924. Mr. Glanz was an active member of the Michigan Chapter of the Society and was prominent in heating, ventilating and plumbing activities in Detroit for many years. He was a member of the *Master Plumbers Association,* the Detroit Yacht Club and Red Run Golf Club.

He is survived by his wife and two children to whom the Officers and Council extend their sincerest sympathy.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade,

the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 33 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by Sept. 15, 1936, these candidates will be ballotted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
BARNES, H. P., Mgr., Johns Manville Sales Corp., Kansas City, Mo.	C. A. Weiss David Caleb	Carl Clegg W. A. Russell
BLUM, HERMAN, JR., Jr. Engr., Crawford, Inc., New Orleans, La.	Arledge Stokes C. B. Gamble	L. L. Hamig O. E. Gammill, Jr.
BRIGHTLY, F. C., JR., Vice Pres., Standard Galvanizing Co., Chicago, Ill.	E. V. Hill A. H. Goelz	G. L. Larson O. W. Armspach
BROWN, M. D., Mech. Draftsman, Northup & O'Brien Archts., Winston-Salem, N. C.	C. A. Rueger, Jr. W. C. Northup (*A.I.A.*)	L. A. O'Brien (*A.I.A.*) G. E. Brewer (*Non-Member*)
CHEN, S. T., Director & Partner, American Engrg. Corp., Shanghai, China.	R. T. Thornton C. C. Cheyney	E. E. Johnson Roswell Farnham
DANIELSON, L. C., Sales Engr., Air Conditioning Co., Russell, Kan.	W. F. Ryan W. J. Scarlett	H. J. Macintire (*A.S.R.E.*) H. G. Strong (*Non-Member*)
DEVER, H. F., Mgr., Minneapolis-Honeywell Reg. Co., Philadelphia, Pa. (*Advancement*).	W. A. Danielson W. E. Kingswell	R. E. Backstrom Albert Buenger
ESTEP, L. G., Design Engr., Kelvinator Corp., Detroit, Mich.	W. G. Boales E. N. McDonnell	J. F. McIntire G. D. Winans
GOODWIN, E. W., SR., Mech. Engr., U. S. Treasury Dept., Washington, D. C.	G. W. Barr W. H. Carrier	C. V. Haynes C. R. Place
KAWASE, SUMIO, Chief Htg. Engr., Eizen Kyoku, Hsinking, Manchoukuo.	Saito Shozo T. Kozu	Kunitaro Fukui O. O. Oaks
KOEHLER, C. S., Sales Engr., Minneapolis-Honeywell Reg. Co., New York, N. Y.	A. J. Offner John Everetts, Jr.	V. J. Cucci L. B. Miller
KRAMINSKY, VICTOR, Managing Director & Chief Engr., Air Cond. & Engrg., Ltd., London, S. W. 1, England.	J. R. Boyle A. G. Sutcliffe	J. M. Frank B. L. Casey
KUEMPEL, L. L., Mgr. Modutrol Div., Minneapolis-Honeywell Reg. Co., Atlanta, Ga. (*Advancement*).	F. B. Rowley C. E. Lewis	G. D. Kingsland L. B. Miller
LAFFOLEY, L. H., Asst. Engr., Canadian Pacific Rly., Montreal, Que., Can.	W. U. Hughes G. L. Wiggs B. V. McCune M. L. Bozelle (*Non-Member*)	G. H. Osborne C. W. Johnson A. E. Rosenkranz (*Non-Member*) Ray Johnson (*Non-Member*)
LEICHNITZ, R. W., Engr. & Estimator, Leichnitz Engrg. Co., Yakima, Wash.	M. F. Thomas W. R. Blackhall Joseph Davis W. E. Voisinet G. L. Wiggs F. G. Phipps G. L. Wiggs C. W. Johnson W. T. Jones D. S. Boyden A. C. Bartlett J. F. G. Miller Walter Fitzgerald (*Non-Member*) Ferdinand Sos (*Non-Member*)	M. S. Woollard H. H. Angus M. C. Beman L. P. Saunders C. W. Johnson G. H. Osborne F. J. Friedman Leo Garneau G. D. Winans J. H. Walker R. T. Pohner (*Non-Member*) H. F. Tapp (*Non-Member*) A. J. MacManus (*Non-Member*) A. W. Barr (*Non-Member*) Henry Bartlett (*Non-Member*) James Danagh (*Non-Member*) G. L. Wiggs G. H. Osborne A. E. McClue (*Non-Member*) O. J. Swisher (*Non-Member*)
MCCRAE, G. W., Engr., John McCrae Mach. & Fdry. Co., Lindsay, Ont., Can.		
MESSENGER, T. I., Power Engr., Buffalo Niagara & Eastern Power Corp., Buffalo, N. Y.		
MORRIS, J. A., Htg. Engr., The James Robertson Co., Ltd., Montreal, Que., Can.		
MURRAY, H. G. S., Sales Engr., Humidaire Co., Ltd., Montreal, Que., Can.		
NEE, R. M., Head of Engrg. & Utilization Div., Edison Elec. Illuminating Co. of Boston, Boston, Mass.		
NELSON, A. W., Mgr., Brockton Oil Heat, Inc., Sharon, Mass.		
OLDES, W. E., Draftsman & Designer, Dept. of Purchase, New York, N. Y.		
PORTER, C. W., Engr., Henry Bartlett, Orlando, Fla.	B. F. McLouth J. H. Van Alsburg C. W. Johnson Leo Garneau J. A. Shanklin J. A. Donnelly	
PRATT, J. C., Air Cond. Engr., Canadian General Elec. Co., Westmount, Que., Can.		
ROSSMAN, S. C., Industrial Hygiene Engr., State Health Dept., Charleston, W. Va.		

RUPLE, P. E., Htg. Contractor, Bradford Oil Burner Co., Bradford, Pa.
SKLAREVSKI, RIMMA, JR., Sales Engr., American Radiator Co., Baltimore, Md.
SMITH, STUART, Br. Mgr., American Radiator Co., Cincinnati, Ohio.
SOMMERFIELD, S. S., Engr., Standard Galvanizing Co., Chicago, Ill.
STEVENS, K. M., Sales Engr., The Powers Regulator Co., Kansas City, Mo.
TERRY, M. C., Chief Engr., Standard Air Cond., Inc., New Rochelle, N. Y.
WATERS, F. A., Sales Engr., Automatic Appliance Corp., Stamford, Conn.
WISSING, C. B., Sales Mgr., Ebner Ice & Cold Storage Co., Vincennes, Ind.

B. C. Candee
M. C. Beman
W. W. Timmis
O. O. Oaks
H. E. Sproull
E. B. Royer
E. V. Hill
G. L. Larson
L. A. Stephenson
Carl Clegg
C. A. Rickner
L. E. Smith
Bernard Leventhal
L. W. Hoyt
H. D. Betz
W. A. Russell
G. F. Erdle
F. A. Fensel (*Non-Member*)
W. R. Zuhlke
F. B. Howell
G. B. Houliston
F. J. Ward
D. W. Nelson
August Sinerda, Jr. (*Non-Member*)
W. A. Russell
E. K. Campbell
Roy Conrad
C. L. Toonder
Elliott Harrington
D. W. McLenegan
C. W. Adams
W. L. Whitaker (*Non-Member*)

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BRADFORD, G. G., Repr., Frick Co., Shanghai, China.
COREY, G. R., Vice Pres., Appliance Engineers, Hartford, Conn.
EDWARDS, J. D., Asst. Director of Research, Aluminum Co. of America, New Kensington, Pa.
FENNER, E. M., Engr., Staples Coal Co., Fall River, Mass.
FRIEDMAN, D. H., JR., Air Cond. Engr., Peoples Gas Co., Miami Beach, Fla.
HUFF, J. M., Mgr. Air Cond. Dept., Silkensen & Co., Inc., Galveston, Texas.
LARSON, C. W., Service Engr., Barnes & Jones, Inc., Jamaica Plain, Mass.
MYTINGER, K. L., Mgr. Air Cond. Div., Fitzgibbons Boiler Co., New York, N. Y.
PARROTT, L. G., Member of Firm, McColl, Snyder & McLean, Detroit, Mich
PETERSON, C. M. F., Instructor in Mech. Engrg., Mass. Inst. of Tech., Cambridge, Mass.
SELIG, E. R., JR., Treas., Fuel Savers, Inc., Harrisburg, Pa.
WORLD, H. P., Mech. & Structural Designer, Mackenzie Waters, Toronto, Ont., Can.

ASSOCIATES

BALDI, GIUSEPPE, Engr., Compagnia Italiana Westinghouse, Torino, Italy.
BYRD, TOM, Sales Dev., American Rolling Mill Co., Middletown, Ohio.
CULLEN, A. G., Executive, Cullen, Inc., Washington, D. C.
FRASER, J. J., Dist Mgr., Minneapolis-Honeywell Reg. Co., Montreal, Que., Can.
GOODRAM, W. E., Htg. Contractor & Partner, Goodram Bros., Hamilton, Ont., Can.
HAMLET, F. A., Mgr., C. A. Dunham Co., Ltd., Montreal, Que., Can.
HITT, J. C., Br. Mgr., Holland Furnace Co., Wheeling, W. Va.
KNAPP, D. S., Br. Mgr., Chamberlin Metal Weather Strip Co., Inc., Minneapolis, Minn.
MAIER, A. H., Supervisor of Htg. & Vtg., Board of Education, Middletown, Ohio.
NESMITH, O. E., Htg. & Vtg. Engr., Williams Oil-O-Matic Htg. Corp., Bloomington, Ill.
PAGE, V. C., Director of Sales, Automatic Htg. & Cooling Systems, Inc., Baltimore, Md.
PREECE, L. W., Sales Mgr. & Engr., Electric Specialty Co., Erie, Pa.
ROBERTSON, J. A. M., Vice Pres., The James Robertson Co., Ltd., Montreal, Que, Can.
ROCHE, I. F., Prov. Mgr., Fess Oil Burners of Can., Ltd., Montreal, Que., Can.
ROWE, I. E., Estimator, Etie Sheet Metal Works, Houston, Texas.
SCHWARTZ, S. B., Consulting Engr., New Orleans, La.
STACY, L. D., Salesman, Ilg Elec. Vtg. Co., Chicago, Ill.
STERNER, D. S., Sales Supervisor, Tennessee Public Service Co., Knoxville, Tenn.
WAGNER, E. A., Pres., Wagner Engrg. Corp., Pittsfield, Mass.
WATKINS, G. B., Director of Research, Libbey-Owens-Ford Glass Co., Toledo, Ohio.
YOUNG, F. H., JR., Mgr., Young Heat Engrg. Co., Billings, Mont.
YOUNG, J. T., JR., Sales Engr., Crane Co. Salt Lake City, Utah.

JUNIORS

ANDERSON, G. A. M., Student, University of Minn., Minneapolis, Minn.
BENSINGER, MARK, Sales Engr., Combustioneer Stoker Corp., Washington, D. C.
DAVIS, G. C., Sales Engr., Northern Public Service Corp., Winnipeg, Man., Can.
DYKES, J. B., Estimator, T. A. Morrison & Co., Ltd., Montreal, Que., Can.
FLINN, G. S., Chief Engr., McGregor's, Inc., Memphis, Tenn.
FOX, E. L., Student, Purdue University, W. Lafayette, Ind.
HAHN, R. F., Sales Engr., Frigidaire Corp., Atlanta, Ga.
HILL, C. F., Engr., Carrier-Brunswick Internat'l., Newark, N. J.
KUBASTA, R. W., Sales Engr., Bryant Air Cond. Corp., New York, N. Y.
LLOYD, E. H., Sales Engr., Washington Gas Light Co., Washington, D. C.
SOLSTAD, L. L., Student, University of Minn., Minneapolis, Minn.
WIERIMAN, W. J., Student, University of Minn., Minneapolis, Minn.

POINTS of DISTINCTION OF MIDWEST WELDING ELLS

★ **LONG TANGENTS**

¼" per inch of fitting diameter. Advantages: (1) Pipe and Ell are lined up more quickly and accurately thus reducing installation time and cost. (2) Short nipples and the extra welds they require are frequently eliminated. (3) Etc.

★ **SAVE PIPE**

When a 12" Midwest Ell is used the tangents alone save 6" of pipe, while the radius of 1½ nominal diameters (instead of one nominal diameter) is responsible for an additional saving of 12" of pipe.

★ **DIMENSIONAL ACCURACY**

and uniformity not otherwise possible result from final working in compression.

★ **LARGE RADIUS**

Radius is 1½ times nominal diameter instead of being only equal to nominal diameter. Larger radius makes welding more convenient and reduces installation time. It also saves pipe and eliminates excessive pressure drop.

★ **STRESS RELIEVED**

Midwest Ells are first made slightly over-size. They are then reheated to a forging heat and reduced to correct size in compression.

★ **UNIFORM WALL THICKNESS**

results from manufacturing process which is used exclusively by Midwest.

★ **GREAT STRENGTH**

Destruction tests have proved Midwest Ells always at least as strong as the corresponding pipe.

90° ELL

45° ELL

VAN STONE NIPPLE

REDUCER

SHAPED NIPPLE

RETURN BEND

BUTT FLANGE

SLIP-ON FLANGE

SADDLE

TEE

SLEEVE

HEAD

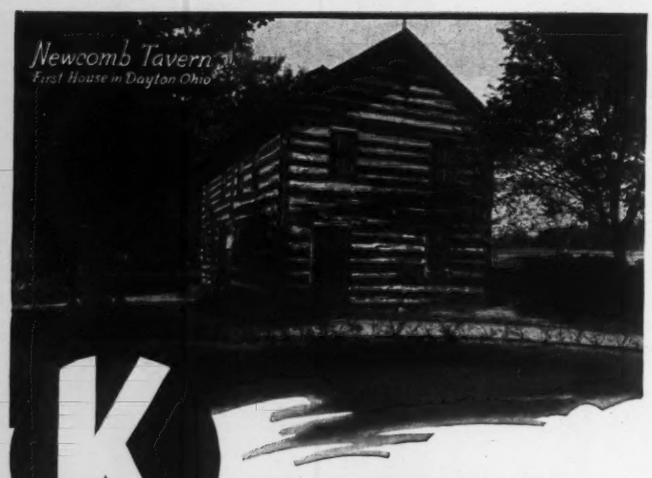
Ask for New Bulletin WF-36

MIDWEST PIPING & SUPPLY COMPANY, Inc.

Main Office: 1450 South Second Street, St. Louis, Missouri

Plants: St. Louis, Passaic (N. J.) and Los Angeles • *Sales Offices:* Chicago—946 Marquette Bldg. • Houston—1716 Second Nat. Bank Bldg. • Los Angeles—520 Anderson St. • New York—(Ballwood Div.) 30 Church St. • Tulsa—533 Mayo Bldg.

MIDWEST
WELDING FITTINGS
IMPROVE PIPING DESIGN AND REDUCE COSTS



K

YESTERDAY AND TODAY

Time was when this unpretentious house was the only house in Dayton. Time also was when Kuhns Brothers were new at the cast fitting business . . . in 1887.

But things have changed and this house is today only a relic . . . Kuhns' early years only a memory.

Today K fittings are produced in tremendous quantities, with the latest of equipment and according to latest practice and up to the most rigid standards.

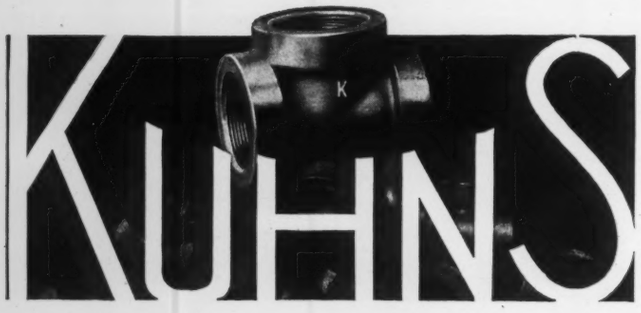
Specify K fittings for your next job. You'll get the quality that has made them a standard line from coast to coast for years and you'll get service.

Standard and extra heavy screwed fittings, American Sprinkler fittings, standard flanged fittings, standard and extra heavy companion flanges and drainage fittings.

Catalog available for Plumbers and Industrial Users

Combined marketing facilities on both "K" cast iron and on M.I.F. malleables. Complete stocks of both at Dayton, Ohio, and Branford, Conn.

KUHNS BROTHERS COMPANY
Dayton, Ohio
1887



Book Reviews

Industrial Dust

"Industrial Dust—Hygienic Significance, Measurement and Control," by Philip Drinker, Professor of Industrial Hygiene, Harvard School of Public Health, and Theodore Hatch, Instructor in Industrial Sanitation, Harvard School of Public Health and Harvard Graduate School of Engineering. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y. 1st edition, 316 + viii pp., 6 x 9 in., clothbound. Price, $4.00.

The authors have succeeded most admirably in this timely book in emphasizing the cooperative nature of the control of the dust hazard in industry, which they point out is the joint duty of the physician and the engineer, as design of the apparatus is an engineering matter but it is often the physician who finally appraises its success.

The physical properties of dusts, fumes, and mists are first described, followed by a discussion of the effects of dusts and fumes upon man. The third chapter is devoted to the physical and chemical factors in pneumoconiosis.

Permissible dustiness is the subject of Chapter IV, and in Chapter V instructions for making dust surveys are given. The next two chapters (VI and VII) comprise a detailed treatment of dust determination, with practical suggestions based on the authors' experience with the various types of sampling instruments and the counting of samples. Chapters VIII and IX are devoted to the determination of particle size, and chemical and mineralogical analyses, respectively.

A general discussion of control of the dust hazard is then given, followed by a lengthy chapter on design of local exhaust systems, and chapters on air cleaning apparatus and dust respirators and air masks. The chapter on air cleaning by filtration is of particular interest.

A bibliography listing 260 references is appended.

Booklets, Reports and Papers

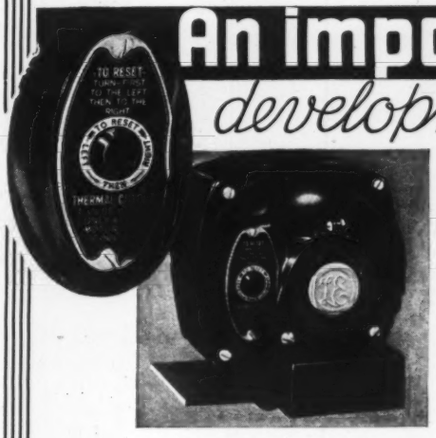
Temperatures of Evaporation of Water into Air

As the paper "The Temperatures of Evaporation of Water Into Air," by W. H. Carrier and Daniel C. Lindsay, which was presented at the annual meeting of the *American Society of Mechanical Engineers,* December, 1924, has been out of print for some time, and because it is of continued importance to the art of air conditioning, reprints have been prepared by the Carrier Engineering Corp., 850 Frelinghuysen Ave., Newark, N. J.

This paper, subtitled "An Experimental Determination of the Laws Governing the Deviation of the Actual Temperature of Evaporation from the Theoretical," reports experiments carried on at Cornell and at the Case School of Applied Science to show that under ideal conditions permitting true adiabatic saturation the wet bulb temperature is actually the temperature of equilibrium represented in the heat equilibrium equation, and also to show how and to what extent the wet bulb temperature observed under ordinary conditions varies from the theoretical equilibrium temperature.

Appendices deal with the process of adiabatic saturation, an approximation of the effect of radiation in raising the wet bulb temperature above the theoretical, a description of the adiabatic saturator and the experimental methods, and a description of the apparatus and experimental methods used in determining the variation of error in the wet bulb temperature with variation in air velocity and wet bulb temperature.

An important development



A Protection for Your Appliance

The Leland Electric Company presents for your approval the thermal release switch — another forward step in producing the ultimate in satisfactory motor operation. It eliminates motor burn-outs—prevents expensive service calls—removes the motor from the line before any permanent damage has been done to either motor or appliance.

Optional on Leland motors sold to drive automatic water systems, oil burners, stokers, water circulators, air conditioners, refrigerators, etc.

Write direct to the company for further details.

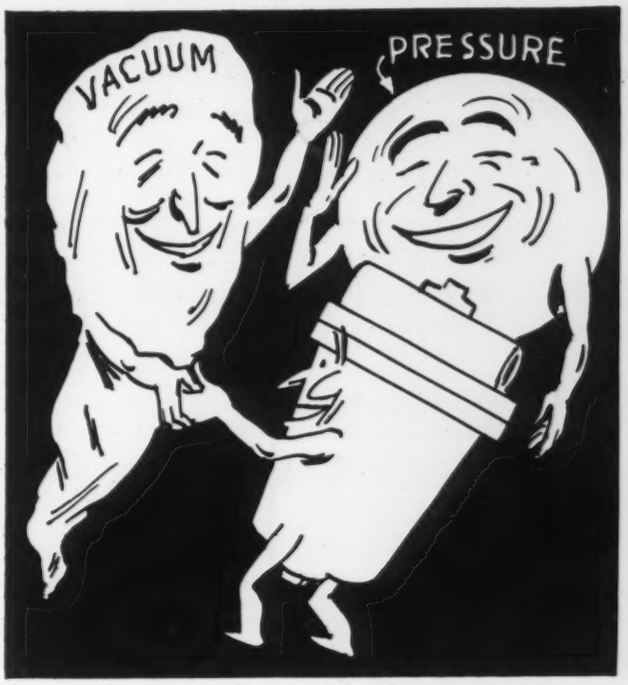
THE LELAND ELECTRIC CO.
Dayton, Ohio

Canadian Address Toronto — Cable Address Lelect

LELAND MOTORS

DAYTON . . . TORONTO . . . PARIS . . . MILAN

VACUUM OR PRESSURE...



Both WELCOME SUPER-SILVERTOP

• Efficient, leak-free operation—that is why Super-Silvertop is welcomed by vacuum or pressure. Some traps appear to operate satisfactorily on pressure systems. But these traps cannot be used on vacuum because they constantly leak steam—steam that means wasted heat—loss of money. On pressure systems this steam loss will be hidden—on vacuum it is immediately apparent.

Before buying traps for any use, ask if the trap will work on vacuum—if the answer is *no,* then that trap definitely leaks steam. Super-Silvertops operate on vacuum—proof that they do not leak steam. • Super-Silvertops save installation time and money—there are no extras to buy or install. They can be inspected without disturbing pipe connections and they average 76% greater capacity.

Remember—the trap that operates on pressure or vacuum—the trap that does not leak steam—is Super-Silvertop, the only complete steam trap.

V. D. ANDERSON COMPANY
1949 WEST 96th STREET • CLEVELAND, OHIO

The Warmth Factor in Comfort at Work

A report entitled "The Warmth Factor in Comfort at Work—a Physiological Study of Heating and Ventilation," by T. Bedford, has been issued by the Industrial Health Research Board of the Medical Research Council, London England, and is printed by His Majesty's Stationery Office, the American agency of which is the British Library of Information, 270 Madison Ave., New York, N. Y. Comprising a 110-page booklet, 6 in. by 9½ in., the price is 2*s.* 0*d.*

This report is devoted to a field investigation of the relation between comfort and environmental warmth which was made in factories and offices under working conditions, and relates to the comfort of persons (mainly young women and girls) engaged in very light work. Included are a survey of the effects of physical environment on the personal feeling of warmth, in which many other studies are referred to; a description of the most comfortable conditions for persons doing light work; a discussion of the relative merits of different instrumental measurements of warmth; and an examination of the relation between the sensation of warmth and temperature of the skin.

From a comparison of correlations of "comfort votes" with instrumental measurements, Dr. Bedford concludes that equivalent temperature and readings of the globe thermometer are better indices of environmental warmth than any of the other instrumental readings considered. It was found that maximum comfort conditions were obtained with an equivalent temperature of 62.3 F, and that this is the degree of warmth that will be found most suitable in workrooms and in other places where the occupants are engaged in sedentary or very light work. This condition is obtained with a globe thermometer reading of 65.1 F, an effective temperature of 60.8 F, a dry bulb temperature of 64.7 F and a dry kata cooling power of 6.1.

The report, of course, applies to conditions in Great Britain, but should be of interest to American engineers as well.

Guides to Government Purchasing

The Machinery Division and the Forest Products Division of the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington, D. C., have made available guide books for American business firms and individuals desiring to do business with various branches of the government. Suggested leads and short cuts for contractors interested in obtaining government business and for prospective bidders on products for government use are included, federal purchasing offices are listed and a section on government purchasing procedure with instructions on proper methods of soliciting inquiries and submitting bids is given.

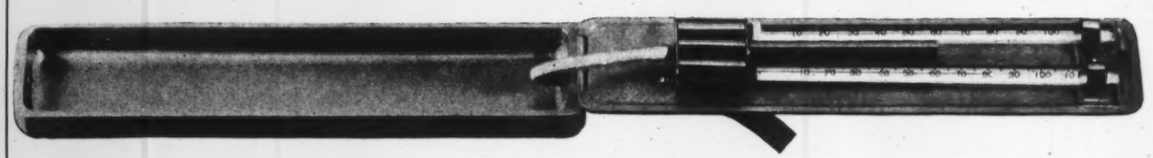
Copies of either report may be had at five cents each from the Bureau of Foreign and Domestic Commerce.

Temperature Control is Health Insurance

A 20 p. booklet, "Temperature Control Is Health Insurance," by Shirley W. Wynne, M. D., has been published by the Temperature Research Foundation of Kelvinator Corp., 420 Lexington Ave., New York, N. Y. Dr. Wynne discusses the importance of mechanical refrigeration for food preservation and briefly evaluates air conditioning as a factor in the well being of America.

Among the unhealthy conditions which Dr. Wynne says are removed by control of temperature and humidity in relation to each other, and by the prevention of overheating by air conditioning, he lists "increased flow of blood; increased heartbeat; increased respiration; decreased vasomotor tone; swelling of the bony structures of the nares; increased pulse beat; increased sweating, increased body and skin temperature; increased metabolism; general lassitude and dizziness. Prevention of these conditions," he remarks, "is obviously a contribution to well-being."

EASY— HUMIDITY —ACCURATE



The Friez Hand Aspirated Psychrometer was derived from the needs of Air-Conditioning for an instrument by which Humidity could be readily and reliably determined.

Instead of whirling—with its difficulties and inaccuracies—this new pocket Psychrometer, with its own case as a handle, is held stationary, while readings are being made. The hand operated air-bulb produces a suction which draws air in fast flow across the thermometers. The thermometers (oval-bore type) can be constantly watched and easily read during the whole process.

Laboratory accuracy is thus attained along with work-a-day facility in use.

Price at Baltimore $15.00

A NEW TOOL
for
Air-Conditioning
Consultants
Engineers
Service Men

JULIEN P. FRIEZ & SONS, INC.
"THE MAKERS OF AMERICA'S WEATHER INSTRUMENTS"
BALTIMORE, MARYLAND

TRIMO MAKES ITS OWN GOOD LUCK

GREATER SERVICE
GREATER STRENGTH
GREATER SAFETY
GREATER DURABILITY

The Red Tag Identifies Every TRIMO

As you need more and more wrenches for heating, piping and air conditioning work, count more and more on TRIMO.

Because you'll have "good luck" with these tested tools — "good luck" that is the direct product of greater strength, safety and the ability of the Trimont Company to deliver quality wrenches on time.

TRIMO is made of Chrome Molybdenum Nickel Alloy Steel — Handle Drop Forged. Use TRIMO Wrenches for good service.

TRIMONT MFG. CO., INC.
Roxbury (Boston) Mass.

TRIMO SAWING VISE SET
pays for itself on first job

1. By making every cut 100% square.
2. By sizing and holding tubing to round while it is being cut.
3. By eliminating damaged tubing which might have to be thrown away.

Photo: N. B. Aukerman

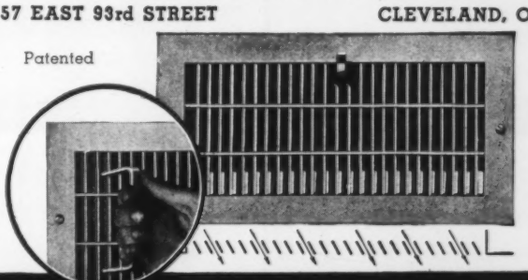
Coordinated Direction

The drum major is more than ornamental. He performs a real service in coordinating the movements of the individuals of his organization.

Independent "Fabrikated" Adjustable Directed Air Flow Registers and Grilles are correctly designed and finished; but their great value to the air conditioning engineer is that they enable him to regulate and coordinate air movements in any space with the utmost effectiveness. Grille bars can be set at any angle, up to 45 degrees, to direct air flows with extreme accuracy. Adjustments can be made either before or any time after installation.

Send for catalog and data book

THE INDEPENDENT REGISTER CO.
3757 EAST 93rd STREET CLEVELAND, OHIO



INDEPENDENT
"Fabrikated" adjustable
REG. U.S. PAT. OFF.
DIRECTED AIR FLOW REGISTERS and GRILLES

DELCO-HEAT
the fastest selling
OIL BURNER
on the market!

A complete line of automatic heating equipment... backed by General Motors

Public acceptance of Delco-Heat has forced it from 300th place to a position among the leaders in the field, in a period of scarcely five years.

The reason for this amazing growth lies in the quality of construction, the economy of operation, and confidence in the reputation of General Motors.

National advertising is now bringing to the attention of the public the unique advantages of the Delco-Heat oil burner, Delco-Heat boiler unit, and the Delco-Heat Conditionair.

PRODUCTS OF GENERAL MOTORS

DELCO-FRIGIDAIRE
CONDITIONING CORPORATION
AUTOMATIC HEATING DAYTON, OHIO *AIR CONDITIONING*

Conventions and Expositions

World Power Conference: September 7-12, Washington, D. C. American National Committee, Interior Bldg., Washington, D. C.

American Society of Mechanical Engineers: Niagara Falls meeting, September 16-19, Hotel Niagara, Niagara Falls, N. Y. Secretary, C. E. Davies, 29 W. 39th St., New York, N. Y.

American Welding Society: Annual meeting, October 19-23, Hotel Cleveland, Cleveland, Ohio. Headquarters Office, 33 W. 39th St., New York, N. Y.

American Gas Association: Convention, week of October 26th, Atlantic City, N. J. Headquarters Office, 420 Lexington Ave., New York, N. Y.

National Association of Practical Refrigerating Engineers: Annual meeting and exhibit, November 10-13, Drake Hotel, Chicago, Ill Secretary, Emerson Brandt, 228 N. LaSalle St., Chicago, Ill.

International Acetylene Association: Annual convention, November 18-20, Jefferson Hotel, St. Louis, Mo. Headquarters Office, 30 E. 42nd St., New York, N. Y.

Twelfth National Exposition of Power and Mechanical Engineering: November 30-December 5, Grand Central Palace, New York, N. Y. Manager, Charles F. Roth, Grand Central Palace, New York, N. Y.

American Society of Mechanical Engineers: Annual meeting, November 30-December 5, New York, N. Y. Secretary, C. E. Davies, 29 W. 39th St., New York, N. Y.

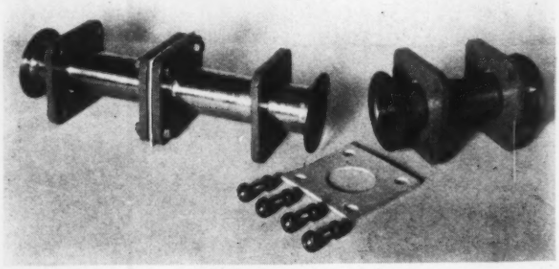
National Warm Air Heating and Air Conditioning Association: Winter meeting, December 15-17, Stevens Hotel, Chicago, Ill. Managing Director, Allen W. Williams, 50 W. Broad St., Columbus, Ohio.

Equipment Developments

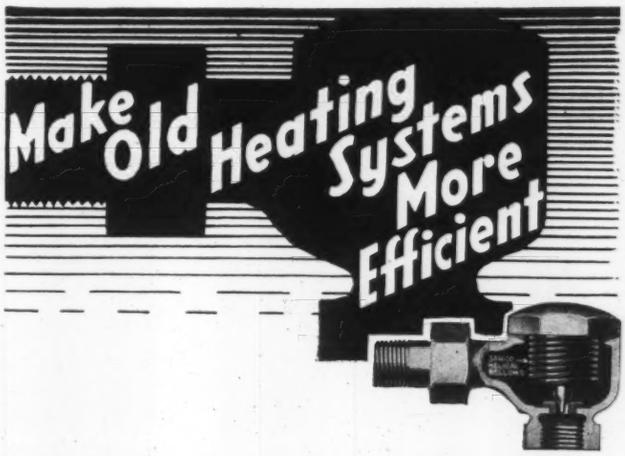
For your convenience in obtaining more information about any of this equipment, see coupon on page 136. Add the new products and companies listed here to your Directory Section which you received in your January 1936 Heating, Piping and Air Conditioning and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed.

Flanged Monel Metal Tubing

No. 1052—Instead of flaring the ends over a backing flange, a new method has been developed whereby the monel flange is pressed out of sheet with a neck for welding to the tube, after slipping a malleable iron backing flange over the tube. In this way the face of the flange is flat and smooth and the inside corner radius is kept at a minimum.



This flanged tubing is immediately available in 1½, 2 and 2½ in. O.D. sizes of welded monel metal tubing, in standard lengths of 10 and 12 ft, and in shorter lengths made to order. It is furnished complete ready for erection at a unit price per length, including backing flanges, bolts and rubber gaskets. Ninety deg ells made by bending thin walled tubing, complete with backing flanges, are available, as are T's made by welding.



Heating systems waste coal and do not deliver the heat they should unless all the radiator traps function efficiently. Replace worn traps with Sarco Radiator Traps and you will be surprised at the difference in the coal bills.

Sarco Radiator Traps have a wide opening which permits them to discharge condensate freely. The large thermostatic element, together with the nature of the volatile fluid it contains, insures maximum closing pressure.

SARCO RADIATOR TRAPS

have longer life because the bellows is formed from a single piece of seamless, helically corrugated bronze tubing of large diameter which gives even distribution of the strain over its entire length.

The head is self-aligning and seats perfectly. The seat can be renewed for a few cents.

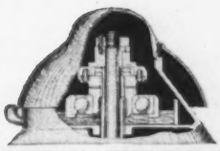
Sarco Radiator Traps operate without noise and cannot air bind or freeze.

Sarco Radiator Traps have been on the market for a quarter of a century.

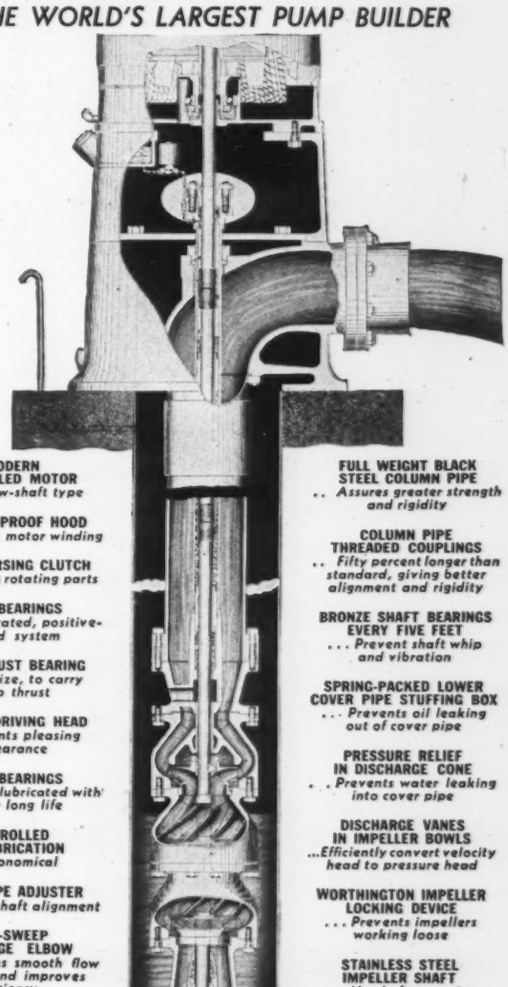
The Sarco line also includes Radiator Inlet Valves, Float Traps, Air Eliminators, Boiler Return Traps, Temperature Regulators, Water Blenders and Strainers.

Write for our interesting Catalog O-45.

SARCO CO., INC.
183 Madison Avenue, New York, N. Y.
Branches in Principal Cities
Sarco Canada Limited, Federal Bldg.
Toronto, Ont., Canada



A DEEP WELL TURBINE PUMP
perfected by
WORTHINGTON
THE WORLD'S LARGEST PUMP BUILDER



MODERN AIR-COOLED MOTOR *... Hollow-shaft type*

WEATHER-PROOF HOOD *.. Protects motor winding*

NON-REVERSING CLUTCH *... Protects rotating parts*

BALL BEARINGS *.. Oil-lubricated, positive-flooded system*

BALL THRUST BEARING *... Oversize, to carry pump thrust*

MODERN DRIVING HEAD *... Presents pleasing appearance*

PUMP BEARINGS *.. Correctly lubricated with oil, for long life*

CONTROLLED OIL LUBRICATION *. . Economical*

COVER PIPE ADJUSTER *... Assures shaft alignment*

LONG-SWEEP DISCHARGE ELBOW *... Maintains smooth flow of water and improves efficiency*

COLUMN PIPE BOLTED TO DRIVING HEAD *... Assures ease in setting or pulling pump*

COVER PIPE *... Protects shaft and bearings from water erosion and corrosion*

STREAM-LINED WATER PASSAGES *... Assure better hydraulic efficiency*

FULL WEIGHT BLACK STEEL COLUMN PIPE *.. Assures greater strength and rigidity*

COLUMN PIPE THREADED COUPLINGS *.. Fifty percent longer than standard, giving better alignment and rigidity*

BRONZE SHAFT BEARINGS EVERY FIVE FEET *... Prevent shaft whip and vibration*

SPRING-PACKED LOWER COVER PIPE STUFFING BOX *... Prevents oil leaking out of cover pipe*

PRESSURE RELIEF IN DISCHARGE CONE *. . Prevents water leaking into cover pipe*

DISCHARGE VANES IN IMPELLER BOWLS *...Efficiently convert velocity head to pressure head*

WORTHINGTON IMPELLER LOCKING DEVICE *... Prevents impellers working loose*

STAINLESS STEEL IMPELLER SHAFT *... No shaft corrosion*

WORTHINGTON CORRECTLY DESIGNED AND APPLIED BRONZE IMPELLERS *...For high pump efficiency*

SHAFT BEARING AT INLET VANE *...Grease-packed, requiring no attention*

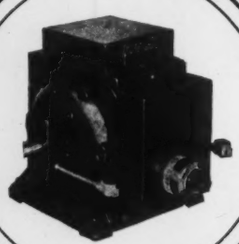
GALVANIZED CORNUCOPIA STRAINER *...Efficiently prevents solids being drawn into pump*

● ***Literature on request***

WORTHINGTON PUMP AND MACHINERY CORPORATION
General Offices: HARRISON, NEW JERSEY
A-36306 *Branch Offices in Principal Cities throughout the World*

WORTHINGTON

Holtzer Cabot
MOTORS
are built Quiet
and
stay Quiet



WILL·GIVE·LONG
QUIET·SERVICE
·· FREE·FROM·TROUBLE
Let us help solve
your Motor Problem
THE HOLTZER-CABOT
ELECTRIC COMPANY
Boston, Mass.
MOTOR SPECIALISTS.

Since the internal diameter of the 1½ in. tubing is essentially the same as that of 1¼ in. I.P.S. pipe, and that of the 2 in. and 2½ in. is the same as pipe of the same nominal size, the tubing can be connected to existing pipe lines by the use of companion flanges. When hooking up with other metals and galvanic action is feared, the bolts can easily be insulated, which, with the rubber gasket, eliminates this possibility, according to the manufacturer.

While the tubing and fittings are at present ready for prompt delivery in the above three sizes only, it is expected that other sizes will be added.—International Nickel Co., 67 Wall St., New York, N. Y.

Four New Unit Heaters

No. 1053—Four new sizes of the "Grid" unit heater have been announced. They are of the same construction as the manufacturer's other units, with all-cast aluminum heating sections bonded with the steam chamber so that no electrolysis is produced to cause corrosion of the heating sections and develop leaks.

The new models have the following capacities at 2 lb steam pressure and 60 F air temperature: 56,750 Btu with 1290 cfm air volume at the fan; 97,500 Btu with 2500 cfm; 158,500 Btu with 4200 cfm; and 248,000 Btu with 5300 cfm.—Unit Heater & Cooler Co., 1002-1024 Third St., Wausau, Wis.

Obtains U. S. Rights on Oxygen Machine

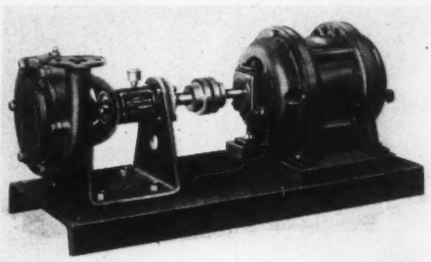
No. 1054—Mr. J. F. Lincoln, president and general manager of The Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio, has returned from a business trip to Germany which he made to investigate a new type of machine for manufacturing oxygen. While there, he completed negotiations with The Messer Co., Frankfort on Main, the designers and patentees, for representation in the United States.

The machine, which is automatic, was developed for users of oxygen for cutting and welding by the acetylene process to enable low cost production of oxygen in their own plants. Due to low first cost and economical operating costs it is believed that this equipment will be of interest to plants who use as little as 500 cu ft of oxygen per day.

Lincoln Electric will handle all negotiations for use of any equipment sold or manufactured under the Messer patents in the U. S.

Centrifugal Acid Pump Announced

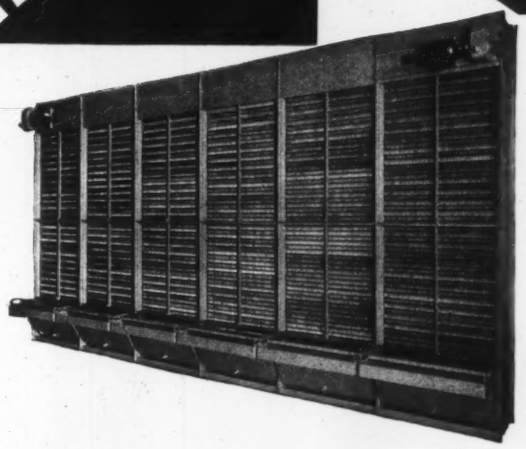
No. 1055—A small, low cost, centrifugal pump made of "Worthite," an acid resistant nickel-chromium-molybdenum steel, was recently announced. All parts of the liquid end are of the alloy, and acid resistance of other parts is obtained by using specially treated steel, coated with chlorinated rubber.



Impeller is of the open type, with three vanes opening down to the hub, subjecting the stuffing box to suction pressure only. The shaft is one solid piece of "Worthite," with impeller attached by lock nuts and key to prevent it from working loose if the motor is started in the wrong direction.

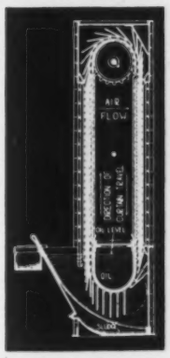
This pump is particularly well adapted to handling most acids and alkalies where medium pressure, transfer pumping is required, states the maker. Available for heads to 70 ft, and capacities to 130 gpm.—Worthington Pump and Machinery Corp., Harrison, N. J.

MAINTENANCE FREE AUTOMATIC AIR FILTRATION



Uniform air-flow assured by self-cleaning louvre plates.

The "DOUBLE-DUTY" Air Filter has been acclaimed an outstanding automatic, self-cleaning filter for heavy duty work by leading manufacturers and mills thru-out the country. Simplicity in construction and design practically eliminates all mechanical attention. "DOUBLE DUTY" filtration only requires servicing to the extent of oil replenishment every three to six months, depending on the dust contents of the air in each individual case.



Cross-section view of filter, showing simplicity of self-cleaning operation.

"INDEPENDENT"

INDEPENDENT AIR FILTER COMPANY
215 WEST OHIO STREET, CHICAGO, ILLINOIS

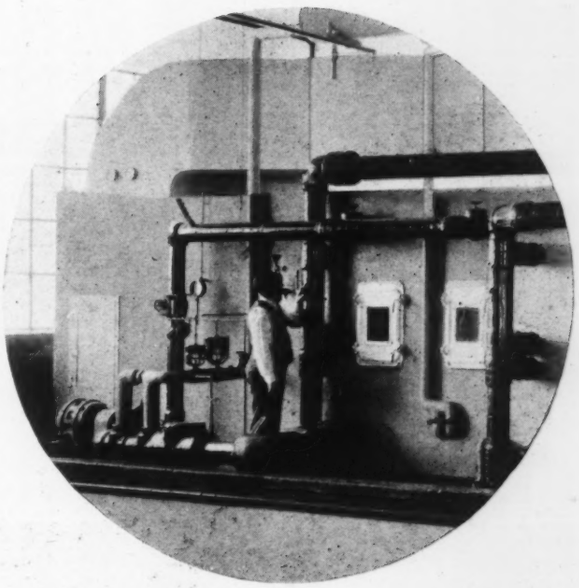
Jointite CORK INSULATION

TRADE MARK

FOR AIR CONDITIONING

The surest way to obtain economical temperature control is to use good cork insulation. "Jointite" Insulation is pure Cork of the finest grade, fabricated by the Mundet process into Corkboard and Moulded Cork Pipe Covering. These products offer the air conditioning industry the same high quality and low transmission coefficient per inch of thickness that have won universal acceptance for Mundet Cork Products. Write for further information, or refer to Sweet's Architectural Catalog.

★ *Machinery vibration is effectively isolated with Mundet Natural Cork Mats.*



"Jointite" Cork Insulation is made in the required thicknesses for insulating all cold lines and ducts.

MUNDET CORK CORPORATION

450 Seventh Avenue New York, N. Y.

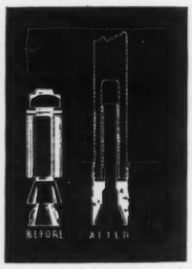
Offices in Principal Cities

Applications of Brazing Alloy Increased

No. 1056—Improvements and refinements in manufacturing "Phos-Copper" brazing alloy have increased its field of application. The new processes include annealing and pickling to insure freedom of any carbonaceous deposit on the surface which might interfere with the production of leak proof joints.

This phosphorous-copper alloy is available in many sizes and shapes, including rod, ribbon, washers, strip, and other shapes. Standard rods are 3 ft in length with $\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, and $\frac{1}{4}$ in. diameter. Ribbon is 0.015 in. thick by 1.25 in. wide. Other shapes for special applications are available. It is applicable to all kinds of copper and copper alloy joints where strength, or gas and liquid tight joints are required, such as bus bar structures, copper tanks, cooling coils, electrical connections, radiators, refrigerators, terminal lugs, water heaters, copper piping, air conditioning systems, and copper smithing, according to the manufacturer.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

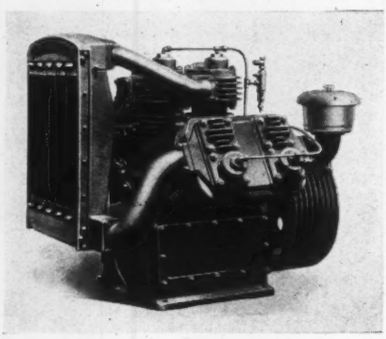
Improved Expansion Bolt



No. 1057—Improved "Life-Time" expansion bolt assures holding power up to the breaking point of the bolt, states the maker. The anchorage material is lead, which absorbs vibrations, is soft, and doesn't crush or break down the masonry. The bolt itself is steel and has a thin, steel-cone jacket under the bolt head, with a lead jacket on the outside. When placed in a hole and driven down with the application tool, the steel cone expands over the head of the bolt and fills all space between the head of bolt and wall of hole, thus preventing the lead from flowing past the head of bolt, and it wedges the bolt head in the hole. The lead jacket expands and flows over the steel cone, filling the hole around the shank of the bolt. A washer slightly larger than the lead jacket is furnished to give a good bearing for driving and expanding the lead jacket.—Chicago Expansion Bolt Co., Rm. 685, 126 S. Clinton St., Chicago, Ill.

New Line of Air Compressors

No. 1058—A line of compact, self-contained three and six cylinder, vertical angle, two stage air compressors with capacities ranging from 142 to 445 cfm has been developed. The three cylinder unit has two low pressure cylinders set opposite each other at an angle, with a high pressure cylinder set vertically between them. The six cylinder unit is set up in the same manner, with two cylinders side by side in each position. The units may be had with V belt drive, direct connected to the motor through a flexible coupling, or with the motor mounted directly on the end of the crankshaft.



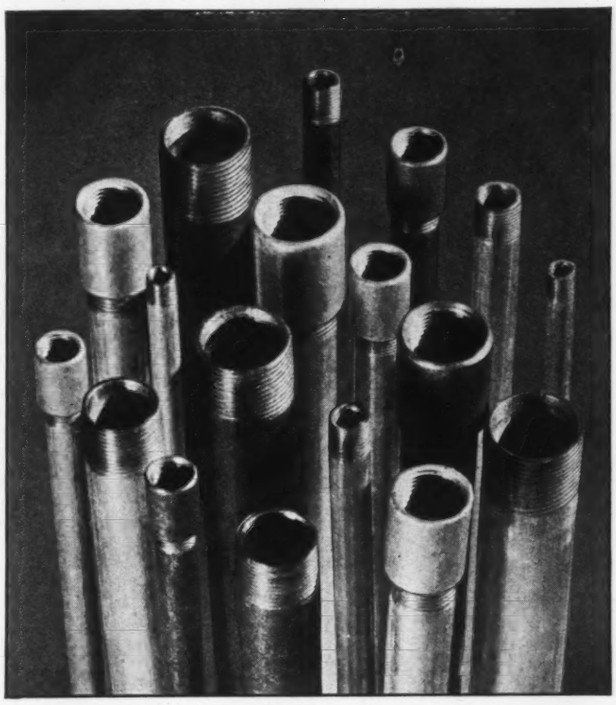
Automotive type pistons with two compression rings, two oil rings, and full floating wrist pins are used on all models. Articulated connecting rods permit the use of a large crank pin bearing and the same center line for all cylinders. A finned, radiator type intercooler, with a fan which draws air through the cooler and over the cylinder head, quickly removes

NOTHING LIKE IT EVER PRINTED
The New Frick Catalog of Ammonia Valves and Fittings

Showing flanged pieces both separately and complete with companion flanges, bolts and gaskets . . . with weights and principal dimensions listed in the same tables . . . and with only one discount applying to everything . . . Frick Catalog H is the answer to your need for a manual of valves and fittings that is convenient to use. Many new items, including repair parts for valves, are presented.

Your copy is waiting.

THERE'S A VAST DIFFERENCE IN STEEL PIPE



. . . AND THIS IS THE REASON

When you think of Fretz-Moon Pipe, don't consider it as ordinary steel pipe. It is made of a different type of material and by an exclusive manufacturing process —both of which combine to produce pipe possessing a high degree of uniformity, ductility and cleanliness not found in steel pipe made by ordinary methods.

The material—steel of evenly high quality, specially rolled into skelp and formed into coils containing as much as 1200 feet in a single length.

The process—an exclusive method of manufacture known as the "continuous process" from which modern scientific instruments and engineering have eliminated all guesswork, all chance. Every inch of pipe made by this process is the same in quality as every other inch. Never under- or over-heated. Always mechanically perfect.

If you would like to know more about the difference in steel pipe, write for the complete story of the "continuous process." It will be sent you in illustrated booklet form.

FRETZ-MOON TUBE CO., INC.
BUTLER • PENNA.

FRETZ-MOON
PIPE
BLACK AND GALVANIZED

ALL-ALLOY

RIDGID WRENCH STRENGTH and PERFORMANCE ARE UNBEATABLE

With its all-over oil hardened chrome molybdenum alloy jaws and new alloy housing and handle, this RIDGID meets all Government and U. S. Navy tests. Housing is guaranteed unbreakable. You'll like the adjusting nut in open housing that spins easily in all sizes 6″ to 60″. And it's made in End Pattern for pipes against flat surfaces. Try it —and you'll understand its popularity.

At your Jobber's.

THE RIDGE TOOL CO., ELYRIA, O.

RIDGID

Reg. U. S. Pat. Off.

RIDGID
TRADE RIDGID MARK
PAT. No. 1727623
UNCONDITIONAL GUARANTEE
If this Housing ever Breaks or Distorts We will replace it Free
THE RIDGE TOOL CO. ELYRIA, O.

RIDGID
Pipe Tools
WRENCHES
CUTTERS
THREADERS
VISES
EXTRACTORS

FEDDERS
Series 3
UNIT HEATERS

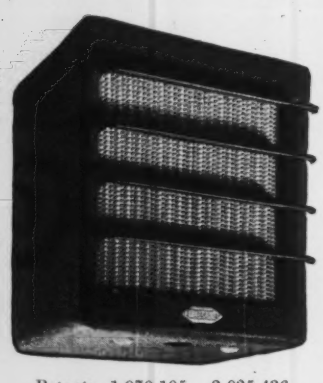
CAN'T COMMIT SUICIDE

The wear and tear on Unit Heaters comes from *INSIDE*, not outside. Fedders Series 3 Unit Heaters provide full protection against the severe expansion stresses within the heating element and between the element and the cabinet due to sudden wide temperature changes between low room temperature and steam.

The element is anchored in the cabinet by patented Full-Floating mountings which not only maintain its alignment, but allow it to expand and contract within the cabinet.

Expansion stresses between neighboring tubes are eliminated by Fedders 3 to 1 streamline tubes and individual convoluted fins. This permits each tube to "give" laterally and independently, rather than being tied to its adjacent tubes from top to bottom.

Curved headers provide extreme strength and eliminate diaphragmatic action thus assuring a stable heating element.



Patents 1,970,105, 2,025,426

Handsome appearance, quieter operation, dependable performance, — you get them ALL in the complete line of Fedders Series 3 Unit Heaters. Write for catalog 542, it shows why they can't commit suicide.

FEDDERS
MANUFACTURING COMPANY
57 Tonawanda Street Buffalo, N. Y.

Are you getting Your Copy of the FEDDERS NEWS?

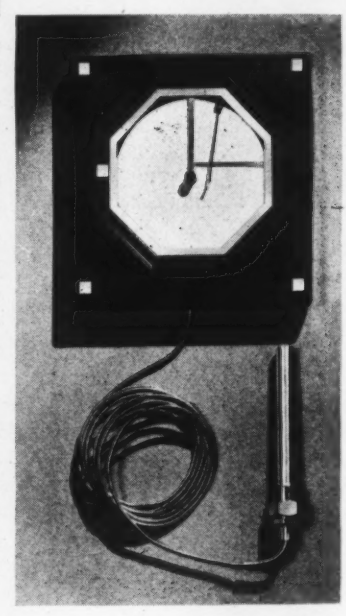
the heat of compression. A large oil reservoir in the crankcase, force-feed lubrication, an oil cooler and an oil filter assure complete and efficient lubrication of all moving parts, according to the maker. The suction and discharge valves are in separate compartments, allowing removal without disturbing the pipe connections. The crankcase is fitted with large cover plates to provide speedy and easy inspection of the running gear.—Worthington Pump and Machinery Corp., Harrison, N. J.

Recording Thermometer for Industrial Service

No. 1059—New 10 in. chart recording thermometer for industrial service has helical spring which is calibrated and sealed in a metal cartridge by the manufacturer, and is welded, together with the capillary tube and sensitive bulb, into a single sealed unit. This complete thermal unit can be readily removed from the instrument without exposing any mechanism or disturbing the instrument mounting. The helical spring, sealed in the cartridge, is protected against dirt and moisture and the possibility of damage by handling.

The absence of multiplying devices is another feature, the helix directly driving the shaft of the pen-arm, and zero adjustment being made by rotating the entire helix within the cartridge.

There are several forms of bulbs available for measuring temperatures in open or closed tanks, pipe lines, air ducts, drying rooms, the average temperature of large areas, etc. Thirty-nine temperature ranges are available between the limits of —20 and +1000 F. The maximum tubing length is 200 ft, and the manufacturer states that the instrument is compensated so that the effects of temperature change on the capillary may be disregarded.



One, 2 or 3 records may be traced on a single chart if it is desired to show flow, CO_2, draft, pressure, etc., in addition to temperature.—Republic Flow Meters Co., 2240 Diversey Pkwy., Chicago, Ill.

Radial Diaphragm Pump for Process Services

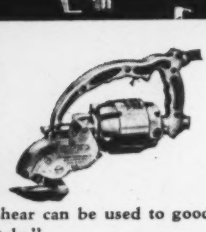
No. 1060**—Radial diaphragm pump has been designed for pumping acids, chemicals or foodstuffs without danger of contamination by lubricants, and for pumping abrasives, sludges and slimes, with minimum wear on interior surfaces. It may be driven by a gear motor, a variable speed motor or a variable speed transmission, and the discharge is a steady flow free from surges. According to the manufacturer, it may be operated efficiently at any speed within its maximum recommended speed, even down to a "mere crawl."

Six pumping chambers are arranged radially around a vertical nickel steel drive shaft and carried on independent brackets attached to a main central housing. Each pumping chamber has an inlet valve and a discharge valve of the weighted rubber ball type. The inlet valves are connected to a manifold arranged to be mounted so that the suction pipe may be placed at any one of six locations; the discharge valves connect with a streamlined spider manifold, the six radial branches converging into a central outlet at the top.

Each pump chamber has a molded ring diaphragm clamped at its outer circumference to the pump chamber and at its inner circumference to a piston. Each piston is connected by a rod with a steel crosshead carried in adjustable guides; at the

"DO THE JOB QUICKLY AND ACCURATELY WITH A UNISHEAR" *says large Chicago company.*

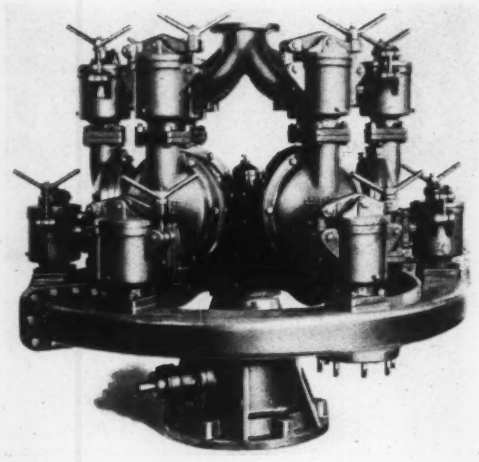
"Picture shows how we use a Unishear to cut a hole in a duct. This can be done either in the shop or on the job. It sometimes happens that in remodeling an air conditioning system it is not possible to move a duct where, for example, it might be necessary to run a new connection from the existing duct. Where it would be difficult to use hand shears a Unishear can be used to good advantage for doing the job quickly and accurately."



This user tells the story of Stanley Unishears from actual experience.

Ask your Stanley distributor for a demonstration; prove it yourself. Or send for descriptive literature.

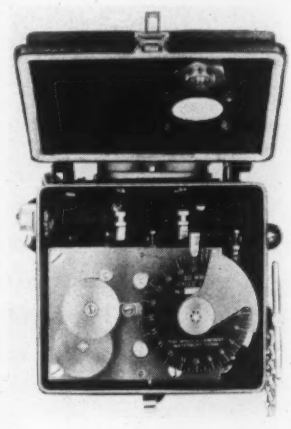
THE STANLEY ELECTRIC TOOL DIVISION
THE STANLEY WORKS
New Britain, Conn.



opposite end of the crosshead a hardened steel roller is mounted on roller bearings, and the crossheads and rollers are operated by an annular "floating eccentric" which imparts positive motion to each crosshead in both directions (suction and discharge).—Logan Engineering Co., 4541 Ravenswood Ave., Chicago, Ill.

Process Cycle Controller Announced

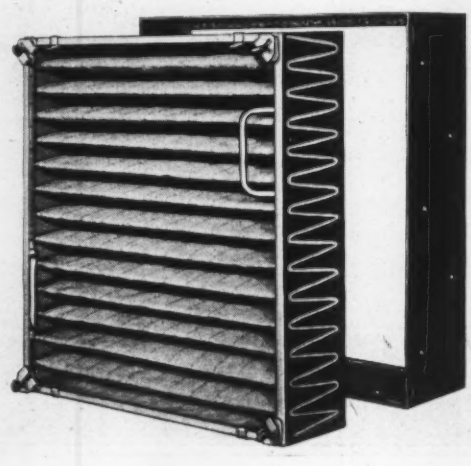
No. 1061—New process cycle controller, known as Model 6088V, has been developed to fulfill the requirements, particularly in the rubber and molded plastics industries, where a variable speed controller is needed. This instrument is suitable for automatically controlling any operation which operates on a cycle that must be changed from time to time. It is equipped with one cam operating one or two patented, leakless, three-way pilot valves, as required by the process. The cam is adjustable to carry out any desired time cycle, regardless of duration, within the range of the controller cam.



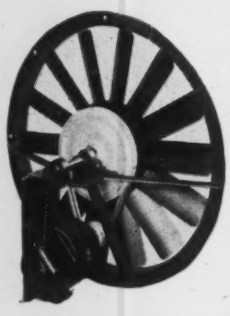
A novel two-speed cam operating mechanism makes possible a multiplicity of speeds obtainable with but a single cam. The variable speed mechanism employed involves no gear shifts, governors, springs, or escapements, and is extremely simple in construction, according to the manufacturer.—The Bristol Co., Waterbury, Conn.

New Air Filter Unit

No. 1062—New "Airmat PL-24" presents the "Airmat" dry filtering material in a compact unit of new design for air con-



THE DE BOTHEZAT



Vari-Speed
BELT DRIVEN FAN

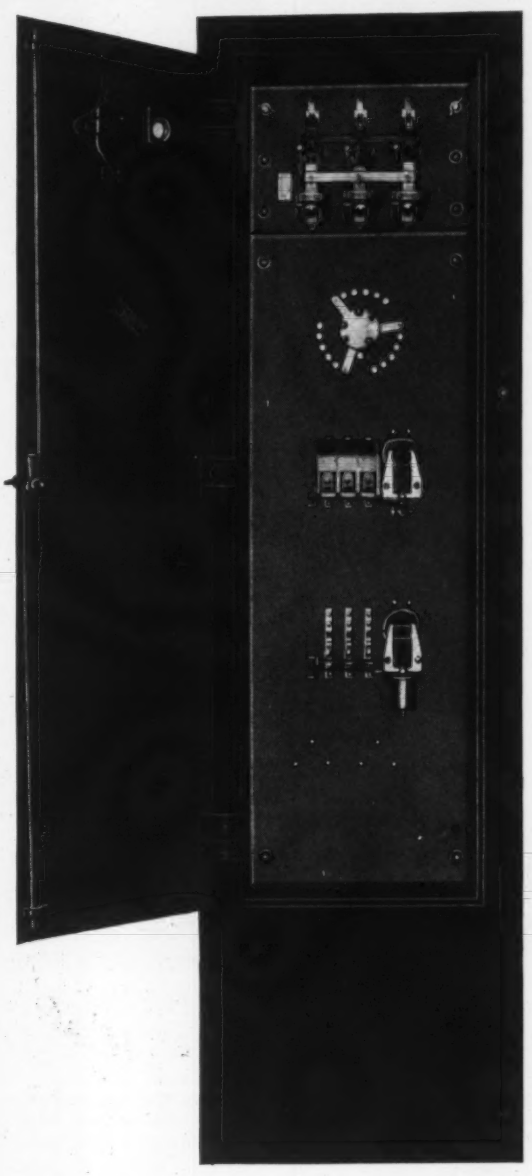
Efficient, adjustable, variable speed fan for dwellings, theatres, clubs, etc.

- Provides 25% variation in speed, without electrical control, by manual adjustment of motor sheave. Adjustment easily made after installation to suit varying conditions.
- Fan and motor are mounted as a unit by mounting ring. No other support required.
- Motor will not overload. Has DeBothezat non-overloading power characteristics.
- Quiet in operation, rugged in construction, economical in power consumption.

Write us for descriptive bulletin and detailed information.

DE BOTHEZAT DIVISION
American Machine and Metals Manufacturing Corporation
100 Sixth Avenue New York, N. Y.

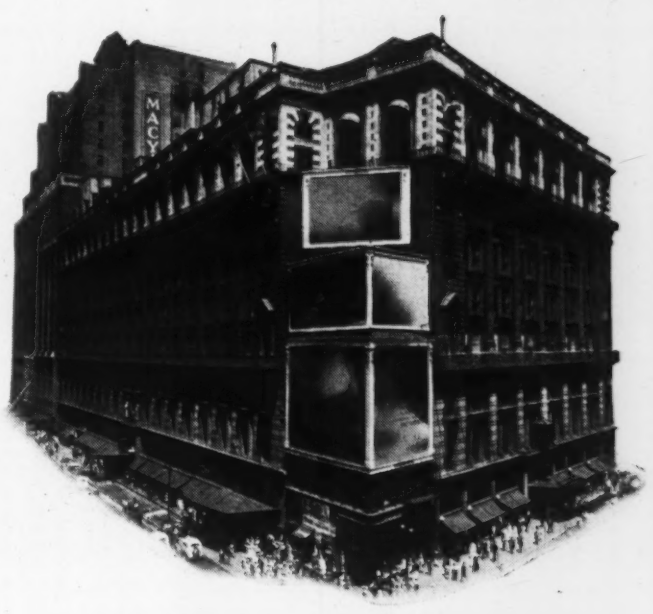
Clark-Sundh



Good appearance as well as electrical and mechanical sturdiness is exemplified in this Ventilating Fan Control panel which is a 2-Step Starter with speed Regulation and with circuit breaker protection. Note the concealed hinges and flush closing door on the cabinet. The speed Regulator may be operated and the circuit breaker reset without opening the door.

THE CLARK CONTROLLER CO.
1146 East 152nd St.
CLEVELAND, OHIO

At MACY'S—



...NOVOID CORKBOARD

assures maximum air-conditioning efficiency

7,250,000 cubic feet of store space—5 entire floors—are now air-cooled at Macy's. And guarding the efficiency of cool air ducts and piping—are Novoid Corkboard and Cork Covering, installed by Robert A. Keasvey Company, New York City.

One of the principal reasons why Novoid is selected for so many important insulation jobs is that it is made from pure granules of cork—a dependable and permanent insulating material. With its millions of cells of entrapped, dead air, cork forms a natural barrier to heat, and also resists moisture.

In Novoid Corkboard, you have this *natural* heat barrier in a practical, easy to use form. Besides its high insulating efficiency, Novoid Corkboard is structurally strong, light in weight and easy to erect. Moreover, when properly installed, this dependable insulation will not settle, pack or deteriorate. Write today for complete information, samples and prices.

CORK IMPORT CORPORATION

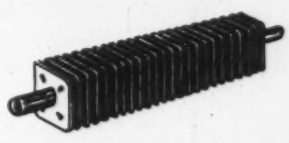
330 West 42d St., New York City
400 West Madison St., Chicago
27 Haymarket Square, Boston
1524 Chestnut St., Philadelphia

NOVOID CORKBOARD

BUSH HAS DEVELOPED THE RIGHT TECHNIQUE

By Constant Effort In One Line

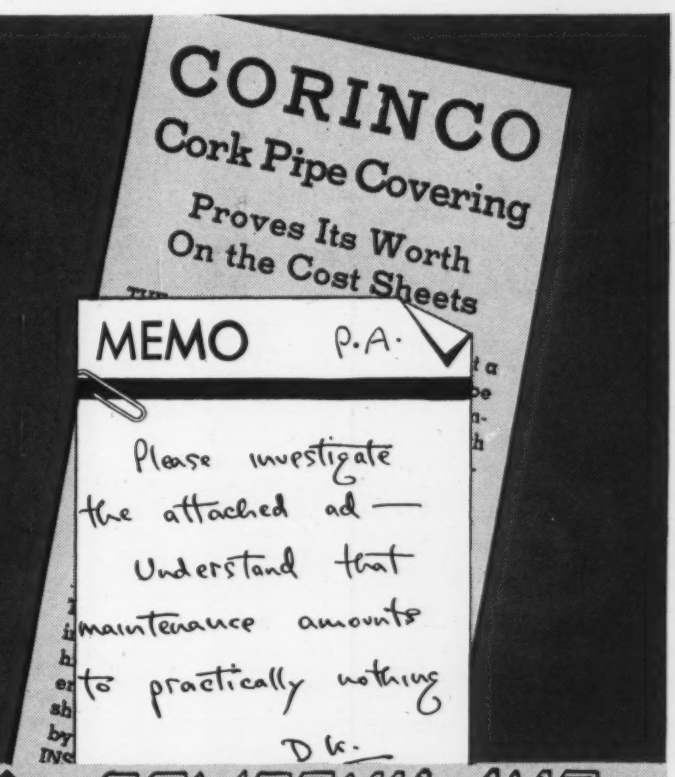
The expert angler through practice and patience develops more than fisherman's luck. We have through years of experience in the manufacture of one line developed experts who can serve you quickly, efficiently and frequently more economically than you can manufacture in your own plant.



There are now 38 combinations of fin and tube sizes and fin spacings in our standard line of finned tubing.

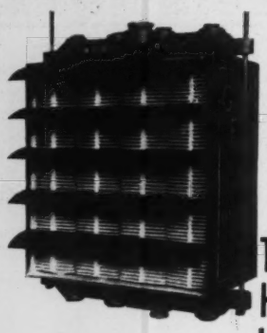
THE BUSH MFG. CO., HARTFORD, CONN.
BRANCH FACTORY 610 N. OAKLEY BLVD.
CHICAGO, ILL.
BRANCH OFFICES: NEW YORK, DETROIT, CHICAGO, DAYTON, CLEVELAND, PHILADELPHIA AND LOS ANGELES

No cold line insulation can be more efficient than its least protected unit. Corinco Cork Pipe Covering is so designed, manufactured and applied that uniform protection is assured at all times.


CORINCO
Cork Pipe Covering
Proves Its Worth
On the Cost Sheets
MEMO P.A.
Please investigate the attached ad — Understand that maintenance amounts to practically nothing
D K.

CORK INSULATION COMPANY INC.
155 EAST 44TH STREET NEW YORK CITY, N. Y.
BRANCHES AND DISTRIBUTORS IN PRINCIPAL CITIES • FACTORY: WILMINGTON, DEL.
MANUFACTURERS OF CORINCO SHEET CORK • CORINCO GRANULATED CORK • CORINCO CORK PIPE COVERING

APPEARANCE ALONE Does Not make an EFFICIENT Unit Heater



It must have the "insides" to deliver the heat you want and expect of a unit heater. It must be free from dissimilar metals which cause electrolysis that causes breakdown of units, leaks, etc. Cabinets are not the working parts—only for eye appeal, not performance.

THAT'S WHY GRID UNIT HEATERS TODAY LOOK LIKE THOSE OF 1929

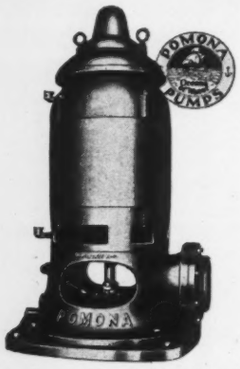
THE *ONLY* UNIT HEATER FUNDAMENTALLY DESIGNED AND MADE RIGHT - FROM THE START

Except for a few minor details, there's no change in design or construction of the Grid Unit Heater. Why? It was originally designed correctly to overcome the faults and weaknesses of other types of heating equipment. No change has been necessary in 8 heating seasons. The Grid has stood the test—without a single failure. That's why today it is distinctive among unit heaters. Let us send you the complete story.

THE UNIT HEATER & COOLER CO.
Wausau, Wisconsin

GRID
UNIT HEATER

Do you buy DOUBLE?



Are you one of those shrewd individuals who consider two points paramount in any purchase? Have you learned that the results obtained in relation to the price paid is the determining factor in establishing value? If you are such a person, then we know Pomona Pumps will interest you.

Consider these things. They are the paramount points. Pomona may not be the cheapest pump to buy, but it is the most economical to own. Pomona may not produce more water from a given source, but it will produce it with less operating expense. Pomona may not make extravagant claims of momentary efficiencies, but it will establish them through trouble-free, multi-year service on the job. Be wise, buy double, buy Pomona.

POMONA PUMP CO.
53 W. Jackson Blvd., Chicago • 206 E. Commercial St., Pomona, Cal.
POMONA TURBINE PUMPS

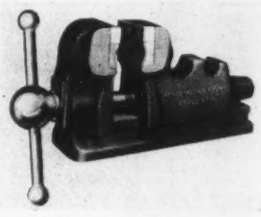
ditioning service. It is of standard unit construction with interchangeable filter element and frame.

The filter element comprises two matched serrated sections which support the filtering medium in deep pleats to provide maximum filtering area and to seal the edges against air leakage. The "Airmat" material, furnished in rolls, is applied to the filter element by means of a simple loader available in either manual or mechanical type. Either six-ply or ten-ply is used, depending upon the requirements.

Unit is 24 in. square by 8 5/16 in. deep, rated at 1000 cfm. Effective filtering surface is 28 sq ft and initial resistence 0.08 in. W.G.—American Air Filter Co., Inc., 107 Central Ave., Louisville, Ky.

Heavy Duty Steamfitters' Vise

No. 1063**—New steamfitters' vise especially designed for heavy pipe work has jaws which are designed to grip all sizes of pipe firmly, and all parts are extra heavy. The tool steel jaw facings, removable, have both flat and double radius curved sections, with the flat sections deeply mill checked. The pipe grip jaw facings are curved on two different radii to hold pipe of various sizes firmly; the vise holds any size pipe from ¼ to 6 in., according to the maker.



Front jaw of vise is fixed and back jaw movable; thus, long lengths of pipe rest on the bench without supports.—Athol Machine & Foundry Co., 621-631 S. Kolmar Ave., Chicago, Ill.

Self-Cleaning Drip Nozzle

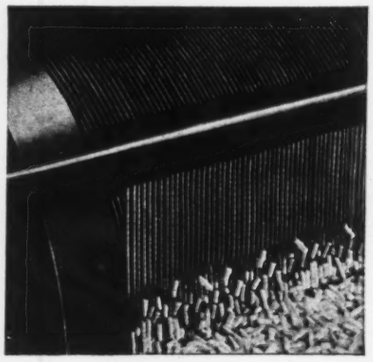
No. 1064—In a self-cleaning drip nozzle recently developed, the liquid passes through nozzle and drips off end. Any quantity up to 9 quarts of water an hour can be obtained by use of stock nozzles, and nozzles of larger capacity can also be furnished. Change in flow is made by turning an adjusting nut.

Each time liquid is turned on or shut off, the parts governing flow move forward and backward, keeping themselves clean. Working parts are of special bronze, and varying pressures will not change the flow, states the maker.

Nozzle is 1/2 in. in diameter and 3¾ in. long and is furnished with 1/8 in. male pipe thread connection.—Rega Mfg. Co., 79 Mt. Hope Ave., Rochester, N. Y.

New Industrial Dryers

No. 1065—New "Aero-Form" method of continuous automatic air drying of wet-solid or plastic materials after filtering, settling or other preliminary treatment, solves problems which have been troublesome for processors of materials of many kinds, according to the manufacturer. Advantages include greater speed not only in drying, but in handling materials to and from the dryer, uniformity in drying, elimination of extreme



PHOS-COPPER

Saved $10,000 IN SIX MONTHS

No special skill is required to braze with Phos-Copper as this picture testifies. The young lady is brazing a refrigerator dehydrator tank.

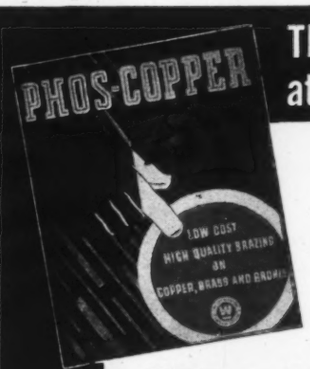
WESTINGHOUSE 1886 W 1936 GOLDEN JUBILEE

It's hard to believe a brazing alloy could mean such savings, but it's true.

After two years of extensive tests, a well-known electrical refrigerator manufacturer standardized on Phos-Copper in preference to all other brazing alloys.

The result was a $10,000 saving in six months . . . a saving made possible by lower first cost . . . by the superiority of joints which meant fewer rejections . . . and because less labor was required in the use of Phos-Copper.

Try Phos-Copper. Then compare costs with any other brazing alloy. You, too, may find worthwhile savings by standardizing on Phos-Copper—the *superior* brazing alloy. J 20112



TRY PHOS-COPPER at our expense ★ ★

WRITE FOR A TRIAL SAMPLE. We will also send you, without obligation, a copy of Booklet 2076 which contains technical and test data on Phos-Copper. Address Dept. 5-N, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Westinghouse

What Does AUDITORIUM Offer You?

Do you realize that Auditorium has over 25 patents issued and many applications pending? These patents do not represent one particular feature of air conditioning nor are they the achievements of any one man.

THEY REPRESENT THE BEST THOUGHT AND EFFORT OF RECOGNIZED AUTHORITIES IN AIR CONDITIONING

and cover a large number of desirable features

They are all available to you upon the basis of a comparatively small royalty which is paid by the owner. For this royalty you are enabled to select the best or more desirable features of any or all of the patents for any installation. You receive the benefits of inventions and practices which are considered HIGHLY VALUABLE by Leaders in the air conditioning industry, which have acknowledged the VALIDITY AND GREAT VALUE of the Auditorium patents by becoming Licensees.

You may secure permission from these Licensees to use any or all of these devices and practices and you have the prestige of being able to tell the owner that your proposal gives him all the advantages which are being enjoyed in the outstanding air conditioning installations in this country.

The following Licensees are authorized to use or to grant permission to use all Auditorium Patents:—

- AMERICAN BLOWER CORPORATION, Detroit, Mich.
- CARRIER ENGINEERING CORP., Newark, N. J.
- GENERAL ELECTRIC COMPANY, Schenectady, N. Y.
- J. O. ROSS ENGINEERING CORP., New York, N. Y.
- THE COOLING & AIR CONDITIONING CORP., *(Division of B. F. Sturtevant Co.)* Hyde Park, Boston, Mass.
- YORK ICE MACHINERY CORPORATION, York, Pa.

AUDITORIUM CONDITIONING CORPORATION

New York Office—17 East 42nd Street
New York

Note:— All Licensees Have Bound Copies Of The Auditorium Patents Which Are Available For Reference.

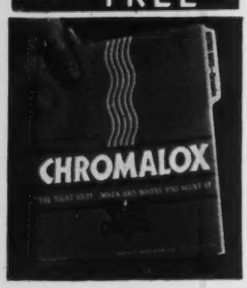
CONTROL
of
HEATING • VENTILATING • AIR CONDITIONING

For controlling heavy oils or steam at high pressure or room temperature control with a 1½° differential or dependable refrigerant control, or handling large flows, or controlling hot water systems, install GENERALS for unfailing operation. Catalog S-182

GENERAL CONTROLS
1505 Broadway, Cleveland, Ohio — 1370 Harrison Street, San Francisco, Calif.
ORIGINATORS OF THE QUIET A. C. SOLENOID

CHROMALOX

This 60-Page book of Electric Heating Facts-FREE



Cut the cost of "stop-and-go" heating

The shop or office equipped with these unit heaters has no worries about an occasional snappy day. No need for discomfort, or numb, inaccurate fingers. No need, either, for firing up a whole steam heating system for only a few hours' heat. Simply snap on a few Chromalox electric unit heaters, throw the heat WHERE you want it, for only as long as it is needed. Heating cost ceases the instant the switch is turned off.

Other types of Chromalox units are particularly adapted for installation in air ducts of AIR CONDITIONING systems. Every heating and air conditioning engineer will want the facts. Mail the coupon with your letterhead, and get the valuable Chromalox Book of Electric Heat.

EDWIN L. WIEGAND CO.,
7610 Thomas Blvd., Pittsburgh, Pa.

Send me the new 60-page CHROMALOX book, and full information on Unit Heaters.

Name .....

Position .....

dusting and disintegration of the material, and freedom from contamination.

The principle is to put the material to be dried into a form that is suitable for fast, economical and uniform drying, this being done as an integral part of the drying process. The material as it is fed to the machine from the filter or settling tank is automatically formed into small rectangular sticks of uniform cross-section and density. As it is being formed, it is simultaneously set by partial drying. These little sticks of material are carried through the dryer without being disturbed or broken, and heated air is driven through the loosely piled bed of sticks so that drying is rapid and uniform.

The illustration shows the drum which forms the small sticks before they enter the dryer.—Proctor & Schwartz, Inc., Seventh St. & Tabor Rd., Philadelphia, Pa.

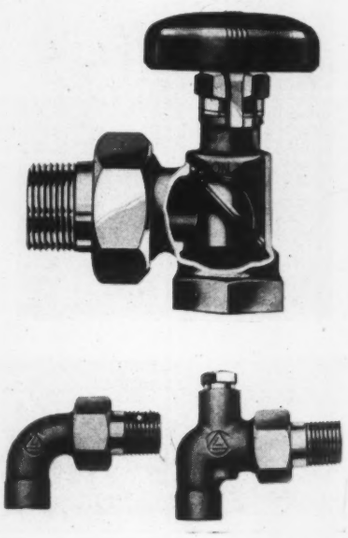
Readability of Thermometers Improved

No. 1066—New thermometer tubing (known as "Binoc") has been developed to improve the readability of mercury-in-glass industrial thermometers. Advantages of design include, according to the manufacturer, more than twice the accustomed angle of vision combined with high magnification of the mercury column, binocular vision (readability with both eyes) at normal or greater than normal distances, triple-lens construction which gathers three times as much light and concentrates it behind the mercury column, and the elimination of confusing empty-bore reflections by the scientifically determined lens angle and extended opaque background. Legibility of the thermometers is further improved by bold numerals and graduations on cream-tinted, non-tarnishing scale. The instruments are available in straight, angle and handled forms.—Taylor Instrument Companies, 95 Ames St., Rochester, N. Y.

Balancing Elbows and Radiator Valves for Hot Water Heating System

No. 1067—Development of balancing elbows and tight-close radiator valves for control of gravity and forced hot water heating systems, was recently announced. The elbows, available in ⅜, ½, and ¾ in. sizes for radiator return connections, make it possible to provide correct flow to each radiator after installation. Adjustable baffle, which can be set after job is in operation without draining system, chokes flow to radiators closest to the boiler and provides free flow to distant radiators.

This balancing feature is also incorporated in straightway fittings for



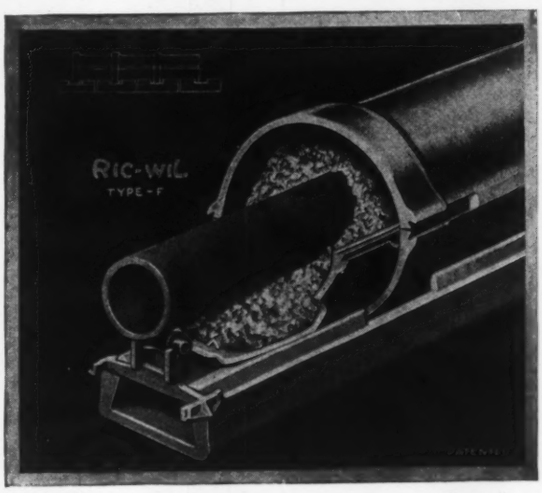
End the Nightmare of Heavy STEAM LOSS!

DOES the familiar ghost of escaping Steam haunt your dreams of lower power costs? If you are conveying Steam underground, in an inadequate or outmoded system—better check up on it. About the time you think you've got this ghost buried, he goes on the loose again—and throws fits into your operating costs—with resulting heat loss, fuel waste, boiler forcing, and inadequate steam supply.

Ric-WiL Conduit is tailor-made for just this sort of thing. A correctly engineered system, it will keep your steam lines (present or contemplated) tight, dry and 90%+efficient. Obtainable in a variety of designs and materials, it secures maximum results on *any* problem of underground steam transmission. Insulation is the famous Ric-wil Watertight Asbestos Dry-paC (other insulations optional). Installation instructions and engineering service drawings furnished—also field supervision if desired. Write for catalog.

The Ric-wiL Co., Union Trust Bldg., Cleveland, Ohio
New York San Francisco Chicago
Agents in principal cities.

Heat loss from conduit in wet soil is over four times that in dry soil. Ric-wiL External Base Drain keeps the soil *dry*.



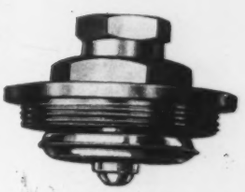
REGISTERED IN U. S. PATENT OFFICE

RIC-WIL

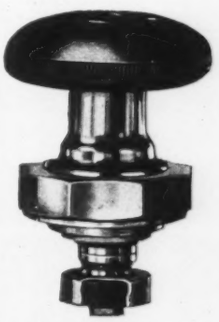
CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

29-S

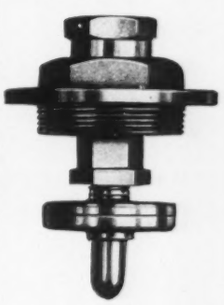
MILVACO MODERNIZATION UNITS ARE EASY AND ECONOMICAL TO INSTALL. They Increase heating system efficiency in addition to reducing fuel consumption.



No. 26-B



29-UA



27-B

MILVACO Modernization Units renew the operating efficiency of old and worn valves and traps. When installing MILVACO Modernization Units it is never necessary to break any line connections. The old valve and trap bodies remain undisturbed in the line.

MILVACO Trap Adaptors and Bonnet Replacements are easily and quickly installed after the old ones are removed and, because they operate with precision accuracy for a longer period of time, it is considerably more economical to use MILVACO.

There is a MILVACO Specialized Modernization Unit to fit every well-known make of radiator valve and trap in general use today.

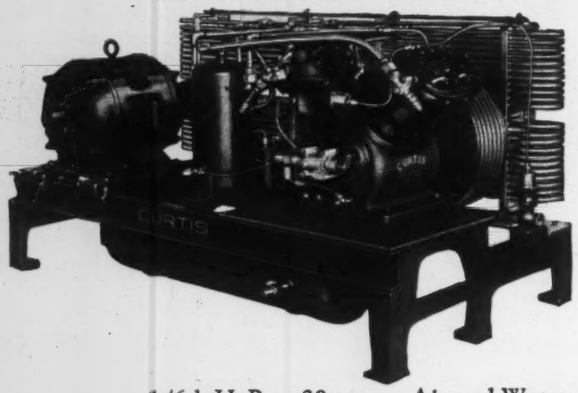
MILVACO Distributors have complete information and are in a position to render valuable assistance to building maintenance engineers and heating contractors who contemplate heating system modernization.

MILWAUKEE VALVE COMPANY

MILWAUKEE Manufacturers of WISCONSIN

MILVACO Heating Specialties—APPROVED Bronze Valves

CURTIS
AIR-CONDITIONING UNITS AND COMMERCIAL REFRIGERATION



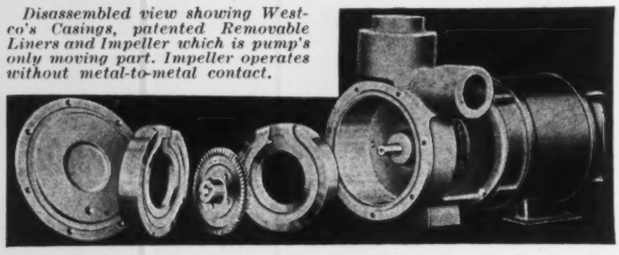
1/6th H. P. to 30 tons—Air and Water cooled. Extra capacity—Slow operating speed—Experienced design—Low up-keep—Rugged construction—Fine materials and Precision workmanship.

Some desirable territories still open.

Advanced design, soundly engineered. 82 successful years—financial stability.

CURTIS CURTIS REFRIGERATING MACHINE CO. Division of CURTIS MANUFACTURING CO. 1950 KIENLEN AVE., ST. LOUIS, MO., U. S. A.

Disassembled view showing Westco's Casings, patented Removable Liners and Impeller which is pump's only moving part. Impeller operates without metal-to-metal contact.



SPECIAL PUMP
for Air Conditioning Duties

THE capacity delivered by this compact, Westco Turbine Pump is NOT materially affected by considerable increase or decrease in head.

Horse power consumption *decreases* in proportion to any head decrease, thereby maintaining efficiency and guarding against motor overload. Patented Removable Liners mean lifetime service for pump casings.

Send Coupon for Details

Fill in coupon and mail today for FREE interesting literature. MICRO-WESTCO, Inc., Bettendorf, Iowa. *Branches: New York, Phila., Chicago, Los Angeles, San Francisco.*

Westco Pumps and Water Systems

MAIL COUPON TODAY

MICRO-WESTCO, Inc., Bettendorf, Iowa, Dept. H-9. *Gentlemen: Please send FREE Literature on Westco Uni-Bilt Pumps.*

Name .....

Address .....

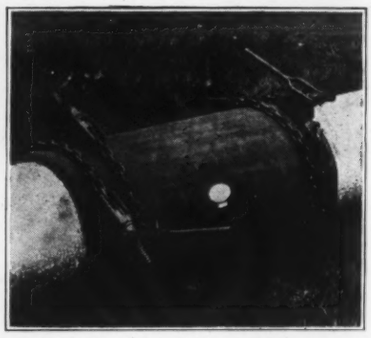
City .....State.....

use on the return connections of convector radiators. Both the balancing elbows and the straightway fittings, besides being supplied with standard pipe thread at the bottom, are furnished with sweat connections for copper pipe jobs.

The radiator valves are made in both packless and pack types for 3/4 in. or 1/2 in. pipe connections, and employ a patented "swinging plate" feature. This plate, concentric with the bore of the valve, provides means for keeping the radiators, especially where a circulator is used, from getting too warm.—American Radiator Co., 40 W. 40th St., New York, N. Y.

Sleeve Clamp for Hydraulic Lines

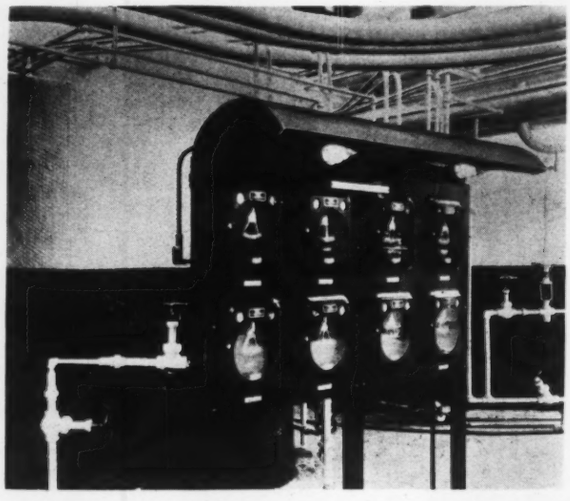
No. 1068—New clamp recently developed for attaching rubber sleeves to hydraulic pipe lines consists of a cast head roughly triangular shape, a 1 in. screw, a long swiveled handle, and a 3/8 in. chain riveted to one end of the screw, and hooked to the block on the other end. The screw is placed at a tangent to the circle for even pressure distribution. The clamp is supplied with either a flat bottomed block or a compound curve that will fit any radius within its capacity. The illustration shows the clamp applied to a pipe line laid on the ground.—The Black Bros. Co., Inc., Mendota, Ill.



Distance Instruments for Flow and Level

No. 1069—New distance transmission system for reading flow and level is based on the use of a pair of synchronous induction motors having wound stators with definite poles which are connected to the alternating current supply source for excitation. The armatures have a three circuit Y winding which connects directly to the rotor winding of the associated motor or motors.

Movement of the rotor of the sending motor unbalances the circuit and requires the rotor of the receiving motor to move exactly the same amount. According to the manufacturer, tests show an accuracy of better than 1/2 of 1 per cent.



The illustration shows the conveniently located board carrying the receiving motors and instrument cases for eight distance level controllers, indicating and controlling the level at eight stations throughout a distillation recovery unit of a solvent extraction plant.—C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

AEROFIN

Light-weight Fan-system Heat Exchange Surface

MORE THAN A PRODUCT

The Result of an Unusual Co-operative Service

AEROFIN CORPORATION is founded on an unusual business principle. It sells only through nationally advertised fan manufacturers and therefore has no individual salesmen. It cooperates exclusively with manufacturers of national reputation in the development of scientifically engineered fan-system heating, cooling and ventilating plants.

Aerofin surface is something more than a product. It is the result of the co-ordinated effort of national fan manufacturers and heating and refrigerating engineers to give you the results you have a right to expect from your forced air distribution system.

AEROFIN DISTRIBUTORS

B. F. Sturtevant Co.
Buffalo Forge Co.
Ilg Electric Ventilating Co.
American Blower Corp.
Clarage Fan Co.
The Bishop & Babcock Mfg. Co.
Garden City Fan Co.
Western Blower Co.
New York Blower Co.

Canada

Canadian Blower & Forge Co.
B. F. Sturtevant Co. of Can., Ltd.
Canadian Sirocco Co.
Sheldon's Limited

All of the above have branches in your vicinity.

Buy Aerofin through the distributors listed above. You can be sure that it will live up to specifications, that it incorporates every improvement that spells high efficiency, reliability, long life and full satisfaction to your client.

Whatever your problem, get the benefit of Aerofin's skill and special engineering knowledge in solving it. Let Aerofin's home office or any of its branches study your requirements. The prompt, personal, technical cooperation of its engineers is at your service.

AEROFIN is sold only by Manufacturers of Nationally Advertised Fan System Apparatus.

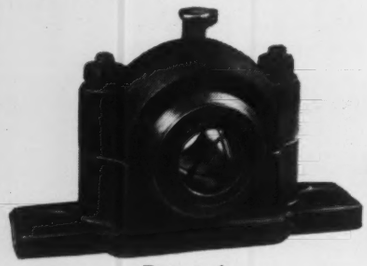
AEROFIN CORPORATION
850 Frelinghuysen Avenue
Newark, N.J.
Chicago Detroit New York Philadelphia

Wrap AIR DUCTS with Ozite *and Reduce Heating Costs!*

Your clients will appreciate the fuel saving assured by insulating air ducts with Ozite Hair Felt. This highly efficient barrier against cold has a thermal conductivity of 0.246 B.t.u.'s. Made entirely of sterilized cattle hair it assures lasting protection. It is preferred by contractors because of its amazingly simple application. It cuts easily and is wrapped on, fitting snugly around elbows and other parts difficult to insulate with other materials. No wires necessary. Write today for specifications and full details.

AMERICAN HAIR & FELT COMPANY
MERCHANDISE MART CHICAGO, ILL.

Ozite HAIR FELT AIR DUCT LINING and DUCT INSULATION
FOR ALL SOUND, HEAT AND COLD INSULATION PURPOSES



3 to 4 times MORE WEAR

Patented

The Randall D.R.O.R. (Double Reservoir Oil Return) pillow block is outstanding in the air conditioning field for extra long, QUIET operation. Precision bored to close tolerances, self-aligning and self-lubricating, it is assurance of long trouble-free use.

In addition to an upper oil reservoir, the Randall D.R.O.R. has a lower, wool packed, reservoir which returns unconsumed oil to the bearing surface through graphite feed plugs.

Randall D.R.O.R. pillow blocks are used as standard equipment by most manufacturers in the air conditioning and warm air heating fields. They can help to improve your product, too. Write for literature, sizes and prices.

Pacific Coast Stocks

Utility Fan and Mfg. Co.
2528 Santa Fe Ave.
Los Angeles, Cal.

C. W. Marwedel
76 First St.
San Francisco, Cal.

Randall GRAPHITE PRODUCTS CORP.
Dept. 910 609 W. Lake St., Chicago, Ill.

for economy of operation and protection of investment, investigate the VILTER FREON COMPRESSOR

THE VILTER "SINCE 1867" MANUFACTURING COMPANY
2148 South First Street
MILWAUKEE, WISCONSIN
REPRESENTATIVES IN PRINCIPAL CITIES

By the best authorities

HEATING, PIPING and AIR CONDITIONING

6 N. Michigan Avenue, Chicago, Ill.

Good, sound, practical information which will help greatly in simplifying your work and which is written by the industry's best authorities. This best describes the contents of every issue of HEATING, PIPING *and* AIR CONDITIONING.

To be thoroughly informed subscribe today. Two Dollars a year.

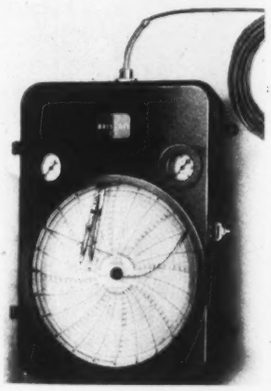
Vest Pocket Draft Gauge

No. 1070—Vest pocket size draft gauge, which, the manufacturer states, is readable to 1/100 in. draft, has a range of 0.14 in. up-draft to 0.10 in. down-draft. Designed for one hand operation, it gives readings quickly. Weight is less than 3 oz.

In use, one end of the draft tube is pressed into a hole at the top of the gauge and the draft tube is inserted into the flue pipe. A finger is placed over the hole at the bottom of the gauge and the gauge is levelled so that the pointer reads zero. When the finger is removed the pointer swings to the correct draft, showing the reading on a clearly marked scale.—Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

Controllers for Temperature, Liquid Level, Pressure and Humidity

No. 1071—New line of controllers for temperature, time-temperature, flow, liquid level, pressure, time-pressure and humidity, known as "Master Free-Vane Controllers" are offered primarily for applications where a greatly reduced sensitivity (wide throttling range) is required, and the load conditions fluctuate over a wide range. Of the pneumatic type, the controller operates on the manufacturer's "Free-Vane" principle of control.



It is equipped with a sensitivity adjustment, an automatic reset, and accessory features which minimize hunting. It is offered to take care of severe conditions encountered in processes, such as sudden load changes, over-shooting, etc., and is a self-contained instrument. According to the maker, it is possible to obtain precision control with this instrument on extremely difficult applications without assistance from the operator—The Bristol Co., Waterbury, Conn.

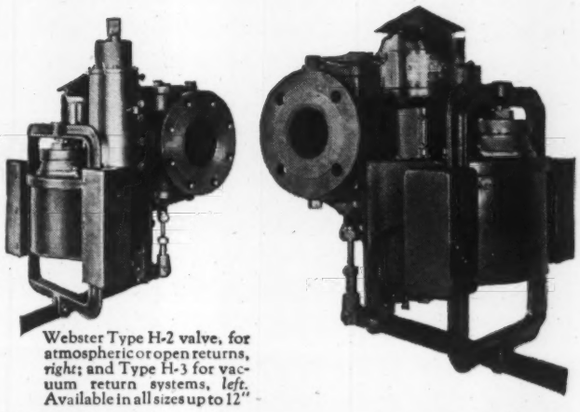
Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 136

No. 2105—AIR CONDITIONERS: Westinghouse Electric & Mfg. Co., Mansfield, O. 4 p. bulletin describing "Mobilaire" self-contained unit for summer air conditioning, illustrating construction and giving description and specifications; hermetically sealed condensing unit is direct connected to a capacitor type ½ hp motor. Also, data sheet giving cooling capacities of unit with various entering air dry bulb temperatures, relative humidities and condenser water temperatures.

No. 2106—AIR CONDITIONING: Frick Co., Waynesboro, Pa. Issue of "The Frick System," Vol. 8, No. 1, describing air conditioning installation at the Standard Caramel Co., Lancaster, Pa., installed in 1910 and in operation today.

No. 2107—BOILERS: Kewanee Boiler Corp., Kewanee, Ill. 20 p. general catalog of steel boilers, giving simplified practice ratings for the complete line of this company's firebox boilers. All diagrams have been remade to conform with the simplified practice, and the specification data and measurements are all new in accordance with the standard ratings for low pressure steel firebox heating boilers, adopted by the *Steel Heating Boiler Institute*. Data are given on firebox riveted boilers in up-draft and smokeless types and welded boilers for hand fired coal, and for oil, gas or stoker firing.



Webster Type H-2 valve, for atmospheric or open returns, *right*; and Type H-3 for vacuum return systems, *left*. Available in all sizes up to 12"

Webster Super-Sensitive Pressure Reducing Valves

Webster Super-Sensitive Pressure Reducing Valves, designed for use in controlling low pressure steam delivery to heating systems, is also applicable to industrial processes requiring unusually close control of pressures. By substituting a compact electric-hydraulic mechanism for the ordinary pressure reducing valve diaphragm, control of delivery pressure within 1/10 lb. per sq. in., plus or minus, is maintained regardless of fluctuating pressures ahead of the valve as high as 125 per sq. in.

By the makers of **Webster** *Systems of Steam Heating*

WARREN WEBSTER & CO., 1635 Federal St., Camden, N. J.
Pioneers of the Vacuum System of Steam Heating—Est. 1888
Branches in 60 principal U. S. Cities—Darling Bros. Ltd., Montreal, Canada

---

KANE Gas Fired Steam Boilers meet all modern requirements for economy and efficiency . . . for safety . . . and for convenience.

Automatically controlled to burn gas *only* when steam is needed, they maintain a fixed working pressure with the very minimum manual attention. And, being gas fired, they eliminate troublesome fuel and ash handling.

Built in two types and 17 sizes . . . there's a KANE to meet your requirements.

Write for details . . . no obligation.

MEARS-KANE-OFELDT INC.

Executive Office and Factory
1903-1915 EAST HAGERT ST. PHILADELPHIA
Branch Offices or Distributors in Principal Cities

The **BIG** and the **LITTLE** of it

NATIONAL

The National trademark is the seal of highest quality for a complete line of correctly engineered and staunchly made air conditioning equipment.

Whether it be a big 10-ft. National Blower type unit heater or a little 1-ft. National utility blower, the same satisfaction for the user is built right into it.

No matter what your customer's requirements are, you can fill them completely and satisfactorily with the National line. Ask us about our 100% agency proposition.

SEND FOR THIS CATALOG

NATIONAL FAN AND BLOWER CORPORATION
540 W. Washington Boulevard, Chicago, Ill.

THE high cost of water is a problem every Air Conditioning Engineer must face. It is possible to save 10, 20, 30 or even 50 per cent by the installation of Layne scientifically engineered Wells and Pumps.

If your water cost is too high, let a Layne hydrological engineer study your problems. Constructive money saving suggestions can be secured without cost or obligation. Layne Pumps and Wells are universally known for high efficiency and low operating costs. For literature, write Layne & Bowler, Inc., Dept. K, Memphis, Tenn.

AFFILIATED COMPANIES

LAYNE-ARKANSAS CO., STUTTGART, ARK.—LAYNE-ATLANTIC CO., NORFOLK, VA.—LAYNE-CENTRAL CO., MEMPHIS, TENN.—LAYNE-NORTHERN CO., INC., MISHAWAKA, IND.—LAYNE-LOUISIANA CO., INC., LAKE CHARLES, LA.—LAYNE-NEW YORK CO., INC., NEW YORK CITY—LAYNE-NORTHWEST CO., MILWAUKEE, WIS.—THE LAYNE-OHIO CO., COLUMBUS, OHIO—LAYNE-BOWLER NEW ENGLAND CO., BOSTON, MASS.—LAYNE-TEXAS CO., HOUSTON, TEX.—LAYNE-WESTERN CO., KANSAS CITY, MO., CHICAGO, ILL., AND MINNEAPOLIS, MINN.—INTERNATIONAL WATER SUPPLY LTD., FORT ERIE, N., ONTARIO, CANADA.

LAYNE PUMPS
LAYNE WELL WATER SYSTEMS

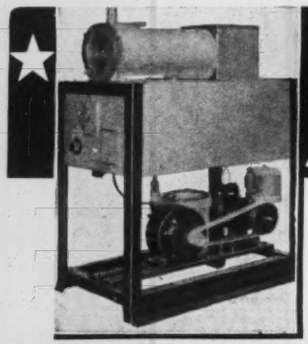
LET ME HELP YOU
keep temperature records

• I am a Practical Recording Thermometer—portable, dependable and economical wherever air-temperature records are needed. Hundreds use me in air conditioning and heating work. I keep a 24-hour record on a 4 inch chart, operating on a spring clock movement. Pen and bi-metal element built in door, swinging out of way when chart is changed. Price $18 fob. Chicago including extra charts, ink and carrying case. Write for 15 Day Trial Inspection offer.

ask your jobber

Practical Instrument Company
2719 N. Ashland, Chicago

PRACTICAL Recording Thermometer



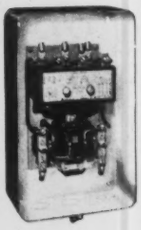
CUT COSTS OF OPERATING
COOLING
AIR CONDITIONING
and HEATING SYSTEMS

Regulated Ozone generation by Electroaire equipment kills odors, freshens and revitalizes air; maximum recirculation—no "stuffy" feeling—no body, musty, moldy or stale tobacco smells.

Profitable Dealer franchises open.

THE ELECTROAIRE CORPORATION
(*Successor to Ozone Pure Airifier Co.*)
1460 W. Congress Street Chicago, Ill.

REMPE
FIN COILS
for Commercial Use
Rempe Co., 340 N. Sacramento Blvd., Chicago, Illinois



BULLETIN 709
AUTOMATIC STARTER
for
squirrel-cage motors

This compact across-the-line solenoid starter provides remote control and no-voltage protection. Its silver alloy contacts require no maintenance. Available in ratings to 15 hp, 110 volts; 30 hp, 220 volts; 50 hp, 440-550 volts. Write for Bulletin 709.

ALLEN-BRADLEY
1335 S. First Street Milwaukee, Wisconsin

No. 2108—COAL: Appalachian Coals, Inc., Transportation Bldg., Cincinnati, O. 4 p. folder listing producing companies which mine high volatile coals distributed by this regional marketing agency.

No. 2109—CONTROLS: Perfex Controls Co., 415 W. Oklahoma Pl., Milwaukee, Wis. Catalog covering this company's line of automatic control equipment for heating, air conditioning and refrigeration.

No. 2110—COOLING SYSTEMS: Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago, Ill. 64 p. catalog giving simplified instructions for estimating "Ilg-Kold" cooling systems, including reasons for and rules pertaining to and helpful in planning systems, as well as suggestions for installing, operating and servicing air conditioning systems. Numerous curves, forms and tables are presented, typical problems are calculated, and detailed information on calculations is given.

No. 2111—DEHYDRATION OF AIR: H. J. Kaufman, 13215 Roselawn Ave., Detroit, Mich. 4 p. leaflet on chemical dehydration of air for air conditioning and manufacturing processes, discussing theory, apparatus and application of dehydrating cabinets with and without cooling.

No. 2112—FLANGES: The Kropp Forge Co., 5301 W. Roosevelt Rd., Chicago, Ill. 24 p. list of stock forged steel flanges, including dimensions, weights and prices on standard flanges in sizes from ¾ in. to 24 in., and data on flange facings, drilling templates, pressure-temperature ratings, threading standards, bursting pressures, and dimensions of standard, extra heavy, and double extra heavy pipe.

No. 2113—FLOOR AND CEILING PLATES: American Radiator Co., 40 W. 40th St., New York, N. Y. Data sheet on "Arco" floor and ceiling plates for copper pipe sizes, with non-tarnish chrome finish.

No. 2114—INSTRUMENTS AND CONTROLS: Julien P. Friez & Sons, Inc., 4 N. Central Ave., Baltimore, Md. 20 p. profusely illustrated booklet on air conditioning instruments and controls, describing the uses of this company's products, including humidistats, windowstats, thermostats, the "Comfortrol," portable temperature and humidity recorders, distant reading temperature and humidity recorders, psychrometers, anemometers, etc.

No. 2115—INSULATION: Keasbey & Mattison Co., Butler Ave., Ambler, Pa. Catalog covering properties and uses of asbestos and magnesia products, including insulations, millboard, asbestos lumber, insulating and refractory cements, packings and building materials.

No. 2116—LUBRICATION: R. & H. Chemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. Data sheet "More About Lubrication," giving information on lubrication of methyl chloride compressors.

No. 2117—LUBRICATION: The Texas Co., 135 E. 42nd St., New York, N. Y. 12 p. issue of "Lubrication," Vol. 22, No. 7, in which is included an article on deep well pump lubrication, with informative diagrams.

No. 2118—MOTORS: The Lincoln Electric Co., 12818 Coit Rd., Cleveland, O. 6 p. bulletin of engineering pointers on the application, selection and installation of totally enclosed, fan cooled, squirrel cage, induction type "Linc-Weld" motors. Features are briefly described, and dimensions, approximate weights and list prices are given.

No. 2119—PIPE HANGERS: The Grabler Mfg. Co., 6565 Broadway, Cleveland, O. Catalog of "Square Gee" pipe hangers and accessories, illustrating and listing some 300 items, among which are newly developed pipe hangers and concrete inserts.

No. 2120—REGULATORS: Young Regulator Co., 4500 Euclid Ave., Cleveland, O. 4 p. bulletin describing and illustrating regulator for controlling and indicating the position of a damper regulating the volume of air flow through a duct, which may be readily set and locked in a permanent position.

No. 2121—STEAM FLOW MEASUREMENT: The Foxboro Co., Foxboro, Mass. 70 p. "Handbook of Steam Flow Measurement," by L. K. Spink, second edition, prepared for the con-

No other unions are ground like Darts! *Special oscillating grinders* were developed to grind Dart's extra wide, spherically accurate, bronze-to-bronze seats that maintain true bearing over the entire seating surface.

Dart bronze, too, is special—an alloy chosen for machinability, resistance to corrosive and electrolytic action, and for resilience to assure tight seating under repeated removal and re-installation.

It takes 18 operations to make a Dart—to give you a better union. Just tell us the size you use most. We'll send you one to try out.

DART UNIONS

E. M. DART MFG. CO., PROVIDENCE, R. I.

Sales Agents: The Fairbanks Company, New York, and all branches. Canadian Factory: Dart Union Company, Ltd., Toronto, Canada.

For Summer and Winter

Air Conditioning Systems

—use MONCRIEF AIR CONDITIONING PIPE AND FITTINGS

with special lock joints. Modern, accurately made, compact. Everything necessary to install a complete air conditioning system.

Send for new catalog.

THE HENRY FURNACE & FOUNDRY COMPANY

3480 E. 49th St. Cleveland, Ohio

LOWER INSTALLATION COSTS

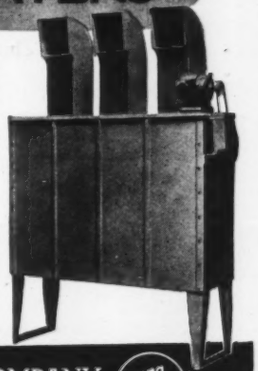
LOWER OPERATING COSTS

Young UNIT HEATERS

Offer the ideal type of heat for factories, warehouses, etc., as well as lower heating costs. From the complete catalog line of Young units you can select a unit to meet your exacting requirements.

Suspension type units are available in 24 Models with capacities from 18,000 B.t.u. to 658,000 B.t.u. per hour. There are ten floor Models varying from 120,000 to 800,000 B.t.u. capacities.

OFFICES IN ALL PRINCIPAL CITIES



YOUNG RADIATOR COMPANY
RACINE, WISCONSIN
Young Quality

SAME DEPENDABLE PERFORMANCE But-

HIGHER EFFICIENCY and LOWER OPERATING COST

Tested side by side in our laboratories, this New Vertical Design actually used 25.2% less power than our Horizontal Design—yet the older Horizontal Design matches ANY other make from the standpoint of performance economy. Yes, we have made marked progress toward lower operating costs. Sizes for every vacuum heating requirement. Write for Bulletins 441 and 442A.

AMERICAN STEAM PUMP COMPANY

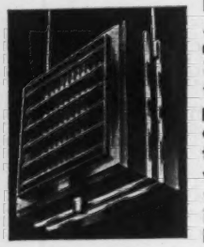
BATTLE CREEK, MICHIGAN . . . Pumps and Pumps Only Since 1873

UNIT HEATERS BY AIRTHERM

A nowly re-styled line of steam and hot water unit heaters manufactured by an organization with years of experience in the unit heater field. Airtherm Unit Heaters are available with propeller or centrifugal type fans in a wide range of sizes for any job. Maximum quietness is secured through the use of new method of four-point motor mounting.

Copper or steel heating elements optional.

Airtherm make a complete line of direct fired unit heaters for gas, oil or coal fuel.



INVESTIGATE THE AIRBLANKET — the newest development in the unit heater field. The Airblanket permits absolute control of air direction to heat the working zone. On your next "high ceiling" job use Airblankets.

Airtherm Manufacturing Co., 1478 S. Vandeventer, St. Louis, Mo.

ARMSTRONG TRAPS (Original Inverted Bucket Type)

For any capacity and for any use

Catalog on Request

ARMSTRONG MACHINE WORKS
874 Maple Street
Three Rivers, Mich.

Stocks in all Principal Cities

GLOBE

STEEL INSERTS

Strength
Convenience
Economy

● Approved by National Board of Fire Underwriters. Write for catalog showing complete line of installation supplies.

THE GLOBE MACHINE & STAMPING CO.
1220 WEST 76TH STREET • CLEVELAND, OHIO

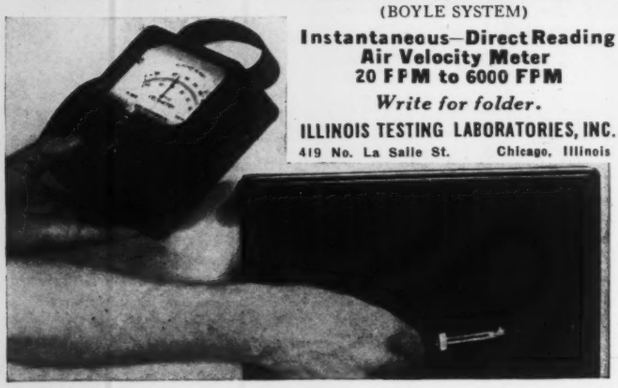
"ALNOR" VELOMETER

(BOYLE SYSTEM)

Instantaneous—Direct Reading Air Velocity Meter
20 FPM to 6000 FPM

Write for folder.

ILLINOIS TESTING LABORATORIES, INC.
419 No. La Salle St. Chicago, Illinois



venience of users of this company's steam flow meters. Among the subjects discussed are the orifice type meter, straightening vanes, derivation of steam flow formulas, flow meter installation, operation of the uniform flow scale integrator, correcting readings to suit changed steam pressures, meters for fluctuating pressure applications, calculation of steam flow, and other data. Many tables and charts are included giving pertinent data in convenient form. Available to operating engineers and others concerned with steam flow problems.

No. 2122—THREAD CUTTING MACHINERY: Landis Machine Co., Inc., Waynesboro, Pa. (a) 15 p. operator's instruction book on heat treated die heads for threading machines, turret lathes and automatic screw machines. (b) 12 p. operator's instruction book covering collapsible taps for straight threads and for tapered threads.

No. 2123—TUBING: Carpenter Steel Co., Welded Alloy Tube Division, 347 Madison Ave., New York, N. Y. 8 p. technical bulletin of helpful data on the properties and uses of stainless welded tubing with description of manufacture, forms of welded tubing products, joining stainless steel tubing, notes on corrosion, working instructions and other information.

No. 2124—UNIT HEATERS: Modine Mfg. Co., 17th St., Racine, Wis. 4 p. bulletin on "Textype" unit heaters especially designed for use in textile mills and other plants where foreign matter and lint are present in the air. Condenser construction is such as practically to eliminate clogging, and the design is explained and capacity and other data presented.

No. 2125—VACUUM PUMPS: Worthington Pump and Machinery Corp., Harrison, N. J. 4 p. bulletin on horizontal simplex air and steam heating vacuum pumps for steam heating, jet and surface condensers, priming suction lines, creosoting work and vacuum pan service. Sizes, capacities, and specifications are given.

No. 2126—VENTILATION: The Swartwout Co., 18511 Euclid Ave., Cleveland, O. 16 p. non-technical treatise on natural ventilation for industrial and commercial buildings, with information on the necessity of ventilation, methods, air requirements, estimating ventilator requirements, and describing rotary ventilators and the "Swartwout-Dexter" heat valve. Numerous installation views are shown, and the features of the equipment described.

No. 2127—VALVES: American Radiator Co., 40 W. 40th St., New York, N. Y. Data sheet describing "Ideal Variport" air valves for radiators and "Arco Hurivent" for mains, the radiator valve having adjustable vent port to vary the venting rate of radiators in a one-pipe steam system.

No. 2128—WATER METERS: Worthington-Gamon Meter Co., Harrison, N. J. 4 p. bulletin on disk, turbine and compound type water meters for cold water service, briefly describing features, and tabulating capacities, dimensions and weights.

FOR YOUR CONVENIENCE

Heating, Piping and Air Conditioning,
6 N. Michigan Ave., Chicago, Ill. [9-36]

Please ask the manufacturer to send me more information about the equipment mentioned under the following reference numbers in "Equipment Developments" and "Recent Trade Literature." (Circle the numbers in which you are interested):

1052	1053	1054	1055	1056	1057	1058
1059	1060	1061	1062	1063	1064	1065
1066	1067	1068	1069	1070	1071	
2105	2106	2107	2108	2109	2110	2111
2112	2113	2114	2115	2116	2117	2118
2119	2120	2121	2122a	2122b	2123	2124
2125	2126	2127	2128			

Name ..... Title .....
Company .....
Address .....
City ..... State .....